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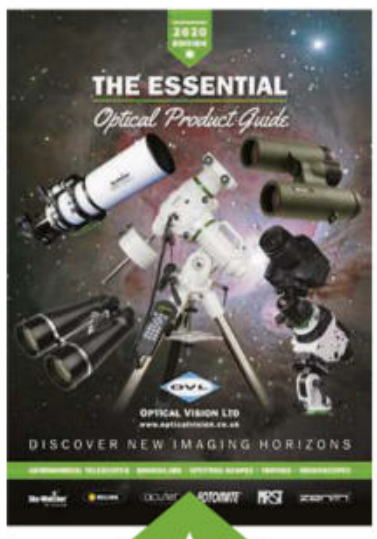

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Welcome

Is there life on Venus? We take a close look at the evidence

As we were working on this issue the news broke of a remarkable observation on Venus: phosphine had been detected in the planet's atmosphere. With no known natural processes on the planet able to account for this molecule, scientists asked what its source was, and as the molecule is known to be produced by microbes here on Earth, the question naturally became, is this a biomarker – a sign of life on Venus?

Our news editor Ezzy Pearson takes a close look at this sensational story in 'Bulletin' on **page 10**, and the diligent work put in by the research team for their detection of phosphine to meet scientific scrutiny. Then on **page 29**, science writer Mark Garlick gives more context to the observation, reminding us that astronomers, including Carl Sagan, have long suggested Venus's clouds could harbour life. On **page 18**, Chris Lintott gives a fascinating insight into filming *The Sky at Night*'s September episode, which aired the day the news was released, and in which he interviewed the project's lead author Professor Jane Greaves.

Elsewhere this issue, we cover another planet that's the focus of the search for life, Mars, on **page 66**. Paul Abel's feature doesn't look at science being done there, however, but at the Red Planet's remarkably good position in the night sky. Its best opposition for a decade may have passed, but it'll still be a great target to observe for many months to come.

And on **page 61** we celebrate a milestone for the International Space Station – its 20th anniversary of crewed operations. Nisha Beerjeraz-Hoyle looks back at its key moments from the past two decades and ponders what comes next in its story, as it reaches a pivotal moment.

Enjoy the issue!

Chris Bramley, Editor

PS Our next issue goes on sale on 19 November 2020.

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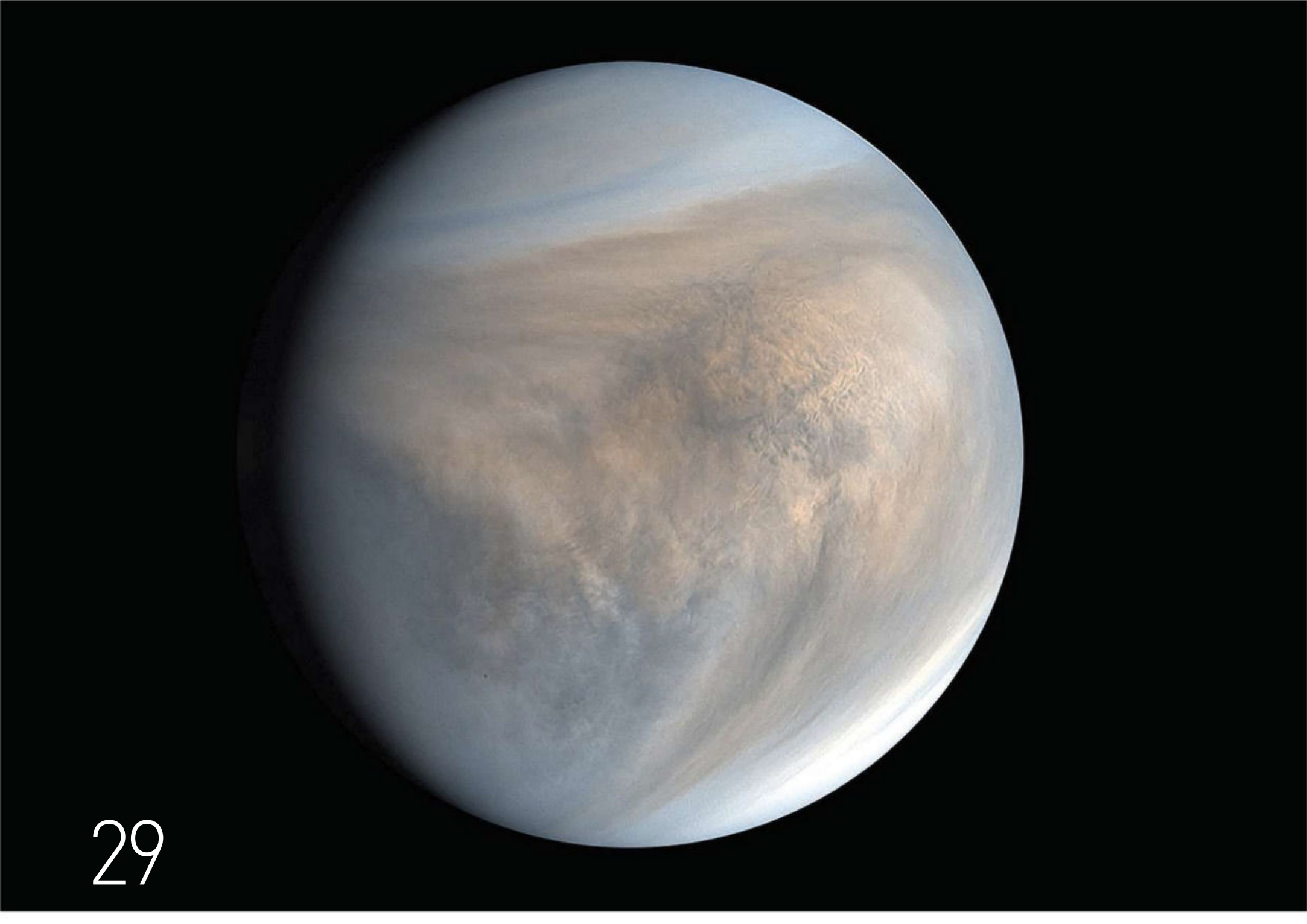

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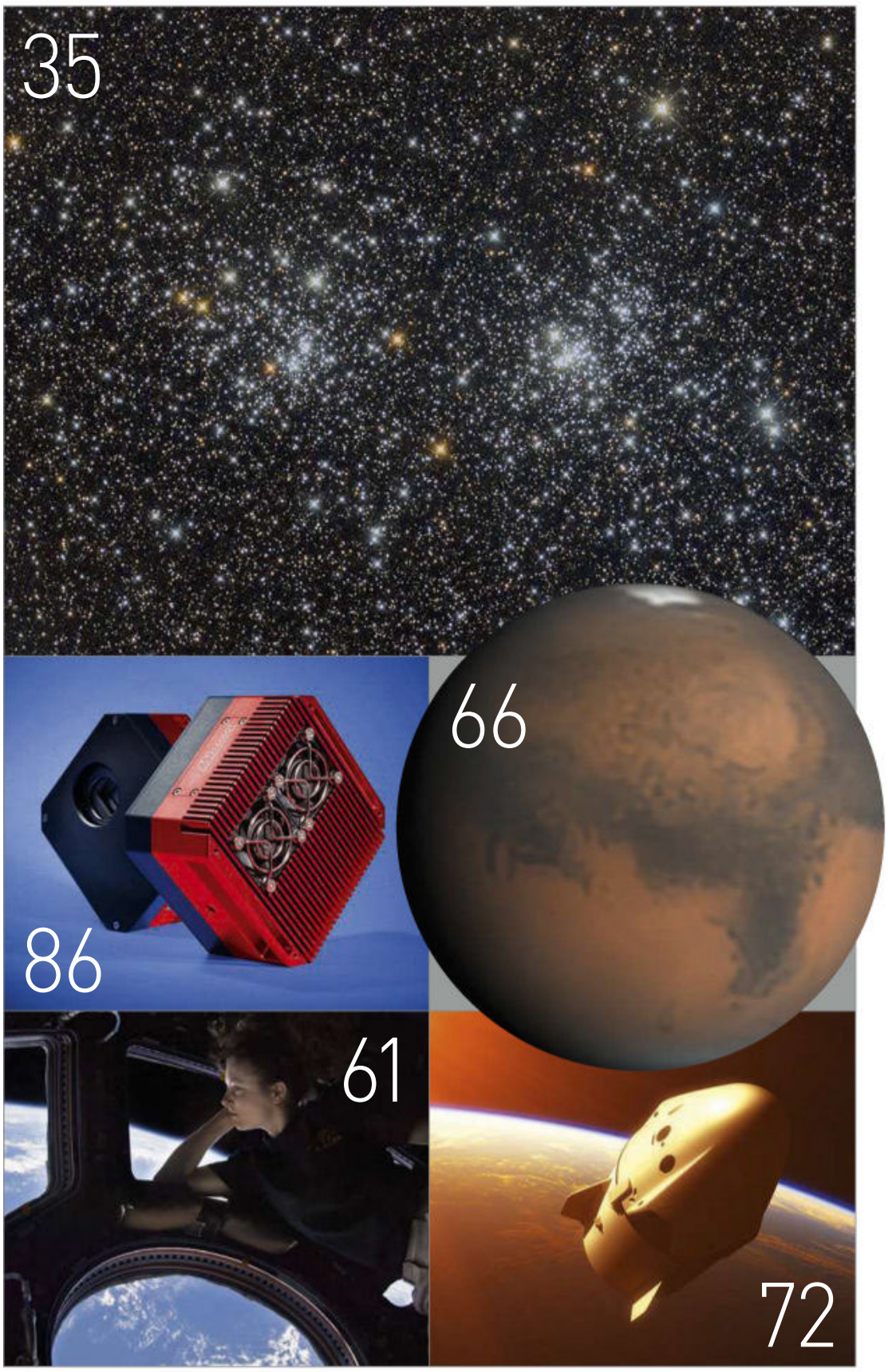
New to astronomy?

To get started, check out our guides and glossary at
www.skyatnightmagazine.com/astronomy-for-beginners



This month's contributors

Nisha Beerjeraz-Hoyle

Space writer

"The ISS is remarkable, and it is a real privilege to share a glimpse of its history and the value it has contributed towards the next chapter of space exploration." **Nisha celebrates 20 years of the ISS,** page 61

Will Gater

Astronomy journalist

"I'll never tire of exploring open star clusters at the eyepiece and this month we're spoilt with so many to choose from across the sky". **Will takes us on a tour of some of November's most impressive star clusters,** page 35

Ezzy Pearson

News editor

"While a trip to space is still beyond my finances at the moment, it was fun to dream about how I could visit the Moon... if only I had the spare billion dollars." **Ezzy looks at the options for getting a ride into space,** page 72

Extra content ONLINE

Visit **www.skyatnightmagazine.com/bonus-content/E6AK8KT/** to access this month's selection of exclusive Bonus Content

NOVEMBER HIGHLIGHTS

Interview: 20 years of the ISS

Veteran NASA astronaut Jeff Williams discusses the history and future of the International Space Station.

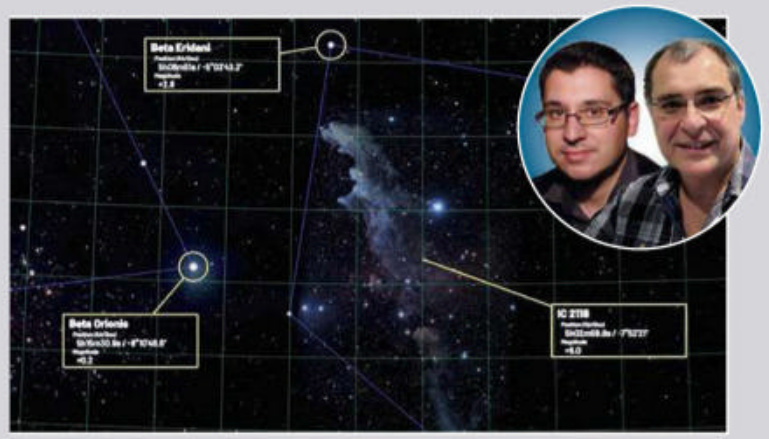
Life on Venus? A *Sky at Night* special

The team get exclusive access to UK astronomers who have made a huge discovery in the search for life beyond Earth.

Audiobook: *Diary of an Apprentice Astronaut*

Listen to chapters from Samantha Cristoforetti's new book, revealing the story behind her 200 days on the ISS.

The Virtual Planetarium



Pete Lawrence and Paul Abel guide us through the best sights to see in the night sky this month.

STAR SPANGLED SPIRAL

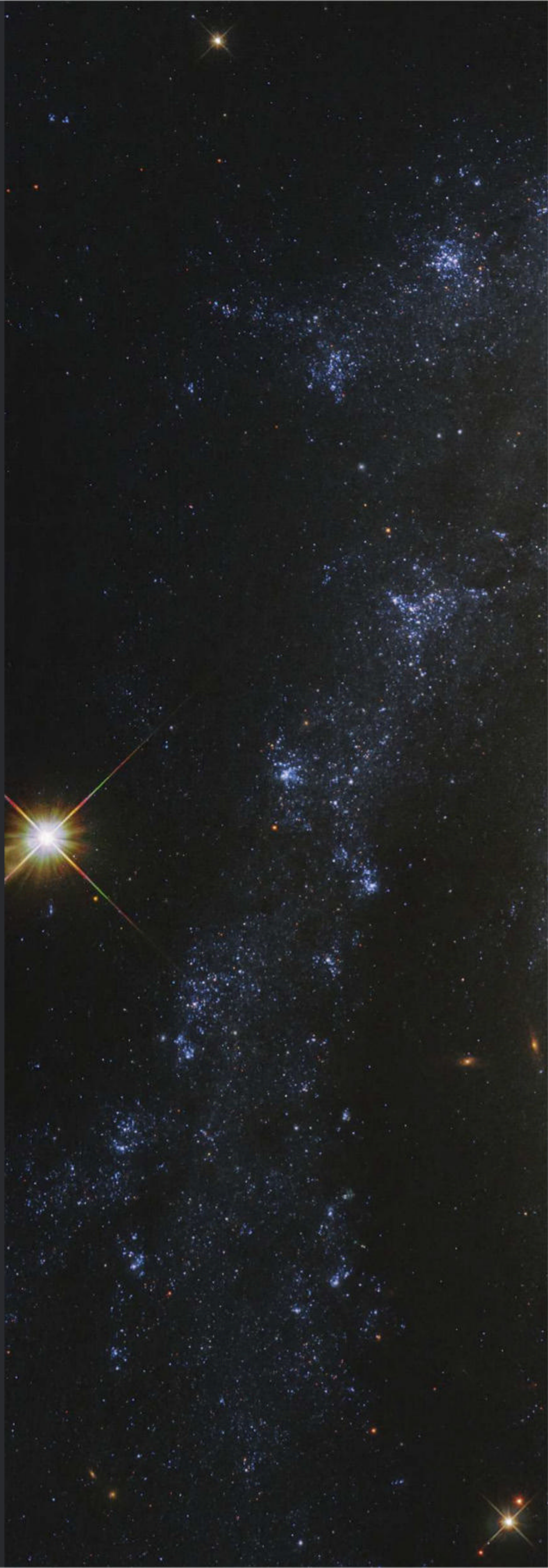
NGC 2835 is part of a galactic quest to explain how cold gas creates hot stars

HUBBLE SPACE TELESCOPE, 14 SEPTEMBER 2020

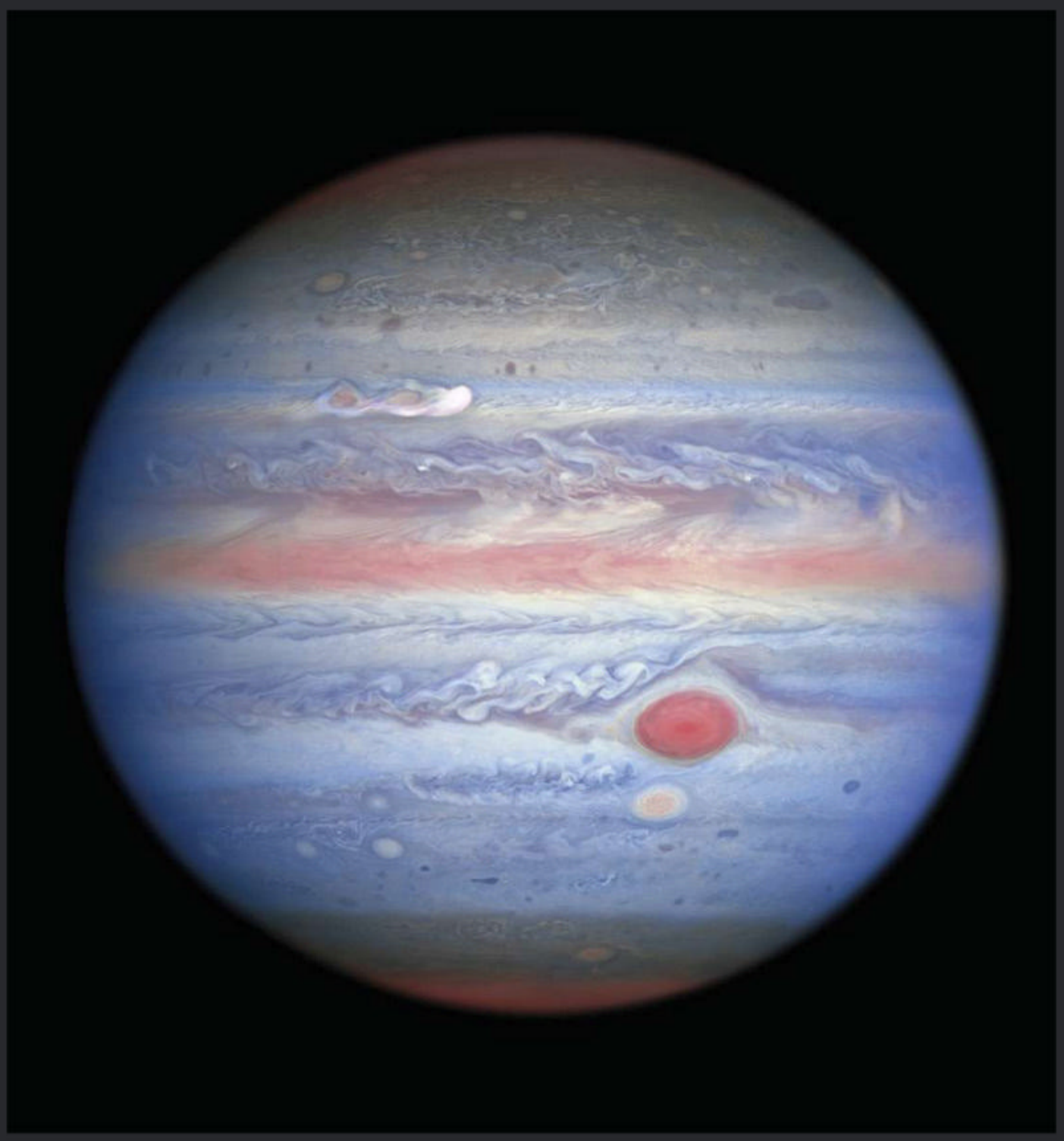
This beautiful face-on spiral galaxy is NGC 2835, found 35 million lightyears away near the head of the constellation of Hydra, the Water Snake. Stretching up to 65,000 lightyears across, more than half the width of the Milky Way, its four distinct arms and one less-defined southern arm teem with sparkling blue clouds. It's within these many pockets of cold, dense gas that clusters of hot, new stars are born. The cold gas is also fuelling the spiral's supermassive black hole, up to 10 million times more massive than our Sun, at the centre of this galaxy.

NGC 2835 is one of over 100,000 star-forming regions and gas clouds outside our Milky Way that are being catalogued for PHANGS-HST project. This unique combined Hubble and ALMA study aims to explore the relationship between young stars, cold molecular gas and the structure of galaxies. Its conclusions will help inform the target list for the long-awaited James Webb Space Telescope, launching next year.

MORE **ONLINE**
A gallery of these and more stunning space images



ESA/HUBBLE & NASA/J. LEE AND THE PHANGS-HST TEAM; ACKNOWLEDGMENT: JUDY SCHMIDT (GEOKZILLA)



ESA/HUBBLE & NASA/W. BLAIR, NASA/ESA, A. SIMON (GODDARD SPACE FLIGHT CENTER) AND M. H. WONG (UNIVERSITY OF CALIFORNIA/BERKELEY) AND THE OPAL TEAM, SOFIA / NASA/JPL-CALTECH/L. ALLEN (HARVARD-SMITHSONIAN CFA) & GOULD'S BELT LEGACY TEAM, ALMA (ESO/NAOJ/NRAO) ESO/ EXETER/KRAUS ET AL, ALMA (ESO/NAOJ/NRAO) DECIN ET AL

△ Ripple effect

HUBBLE SPACE TELESCOPE, 28 AUGUST 2020

This gossamer veil, 2,400 lightyears away in Cygnus, is the ethereal remains of a star's death around 20,000 years ago. Imaged by the Hubble Space Telescope, this is just a small section of the blast wave created when a colossal star, 20 times larger than the Sun, went supernova. It has since expanded 60 lightyears from the blast's centre and continues to travel outwards at 350km/s.

◁ Jupiter in a new light

HUBBLE SPACE TELESCOPE, 25 AUGUST 2020

This Hubble image combines near-infrared, visible and ultraviolet light to reveal Jupiter in pastel shades. In its multi-wavelength livery, the blue areas show ultraviolet light reflected off the planet, while the atmosphere at higher altitude appears red. It also reveals a new, bright white, extended storm to the upper left, which erupted on 18 August and is travelling at 560km/h.

◁ Feeding the stars

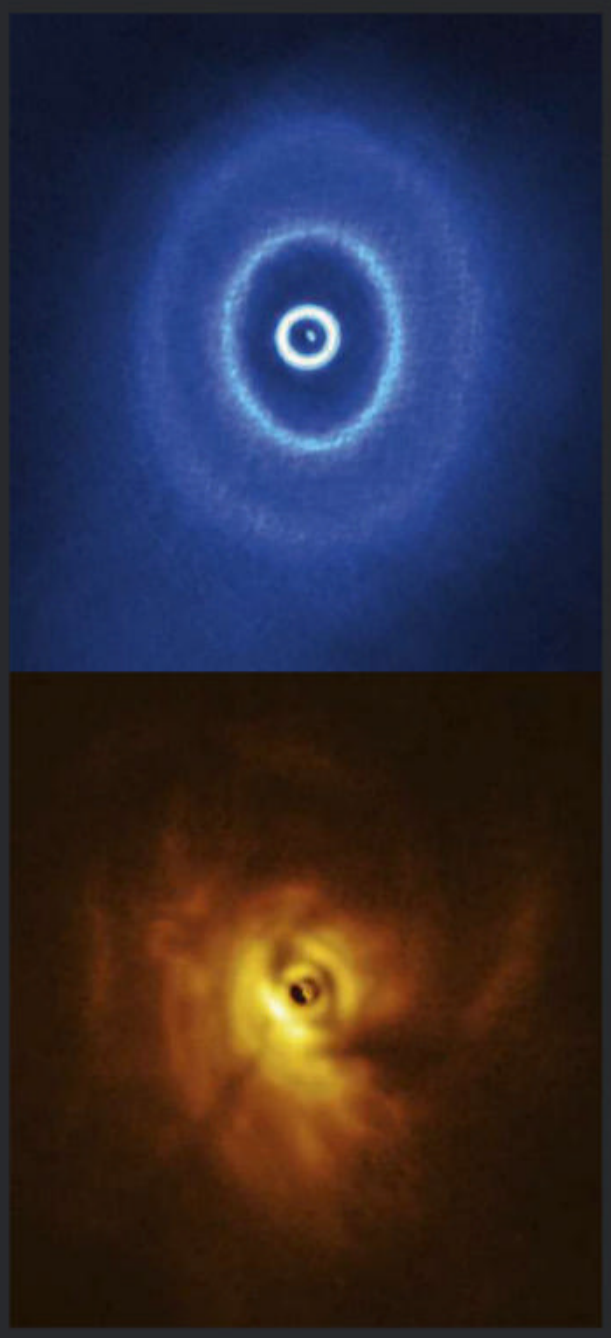
SOFIA/SPITZER SPACE TELESCOPE, 20 AUGUST 2020

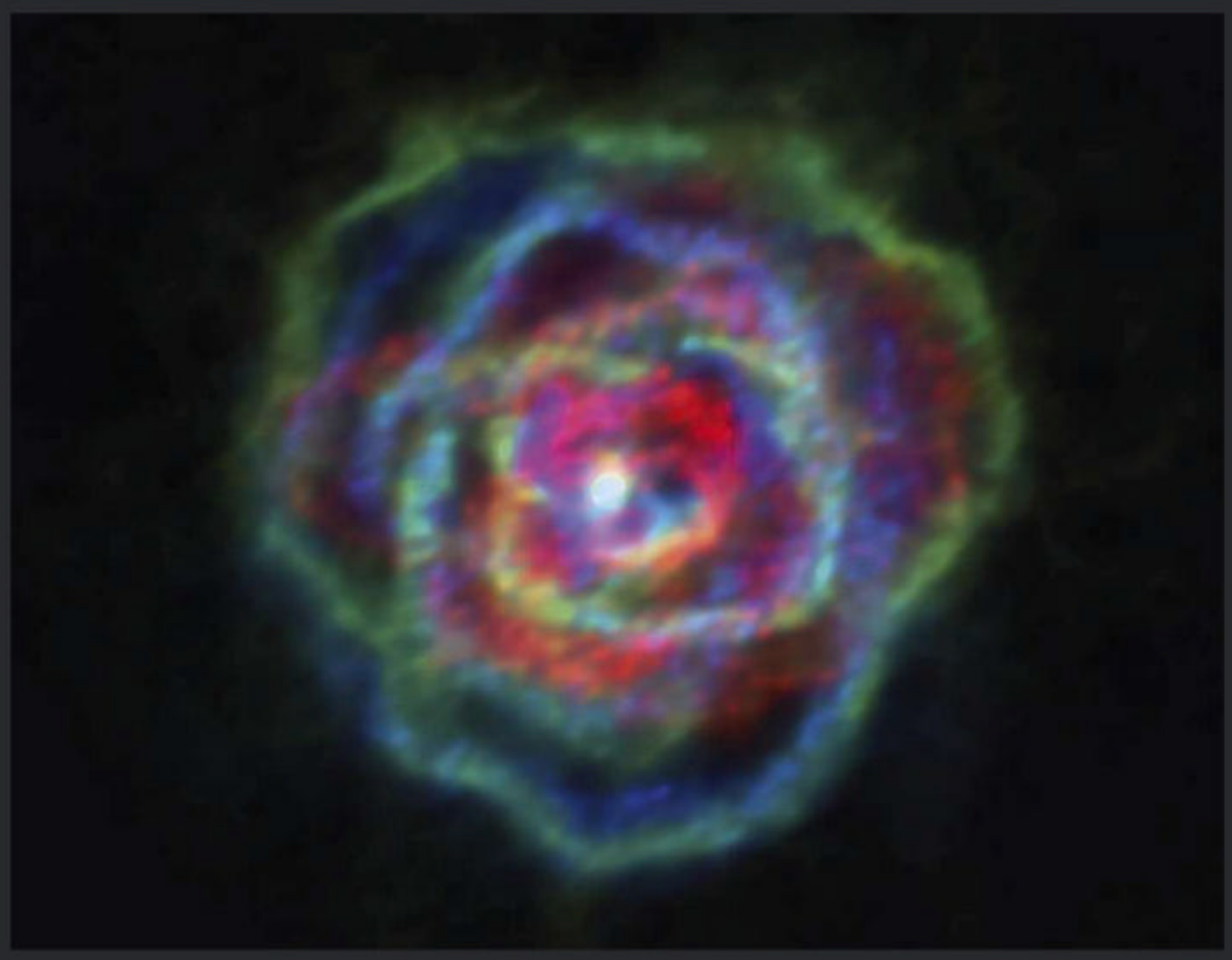
Looking like the strokes of an artist's brush on the celestial canvas, these lines are magnetic fields that are feeding materials into an area of new star formation, the Serpens South star cluster. They are revealed by the HAWC+ infrared instrument on board the SOFIA airborne observatory, which is able to observe dust grains as they align perpendicular to the magnetic fields.

▽ Blasted bloom

ATACAMA LARGE MILLIMETER/ SUBMILLIMETER ARRAY, 21 SEPTEMBER 2020

It may resemble a delicate flower, but this new ALMA image shows something far less serene: stellar winds raging up to a million times stronger than those from our own Sun. They are blasting from red giant star R Aquilae, one of several red giants whose winds have been shown to blow out not spherically as expected, but in irregular shapes. One theory is that the patterns indicate the influence of another star or giant planet nearby.





◁ A tilted disc

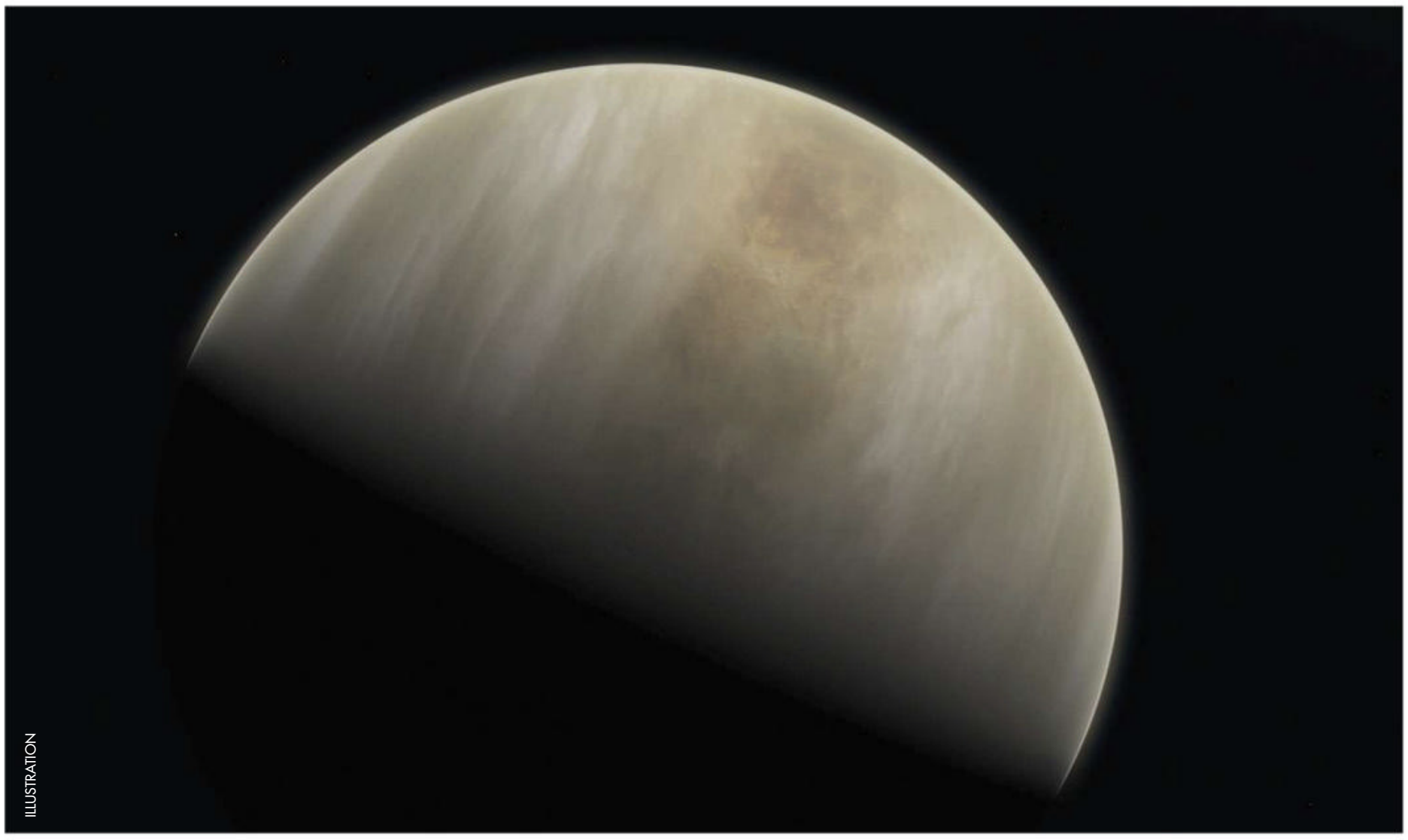
ALMA/VERY LARGE TELESCOPE, 3 SEPTEMBER 2020

While all the planets and moons in our Solar System orbit on nearly the same plane, things are a bit different in triple-star system GW Orionis. Images from ALMA (top) and ESO's Very Large Telescope (bottom) show that it has highly skewed inner rings of gas and grit, deformed by the movements of the three stars at its centre. This is the first direct evidence that groups of stars can warp and tear apart their protoplanetary discs.

BULLETIN

Chemical linked to life found on Venus

The clouds above the planet contain phosphine, which is produced by bacteria on Earth



ILLUSTRATION

ESO/M. KORNMESSER & NASA/JPL/CALTECH, ESO/M. KORNMESSER/L. CALÇADA, © PLANET-C PROJECT TEAM

Could life be hiding in the clouds above Venus? Possibly, according to astronomers who announced on 14 September that they'd found a rare molecule, phosphine, present in the atmosphere of our neighbouring planet.

"The reason for the excitement is that phosphine gas on Earth is made by microorganisms that live in oxygen -free environments," says Jane Greaves from Cardiff University, who led the observations to track down the molecule. "There is a chance that we have detected some kind of living organisms in the clouds of Venus."

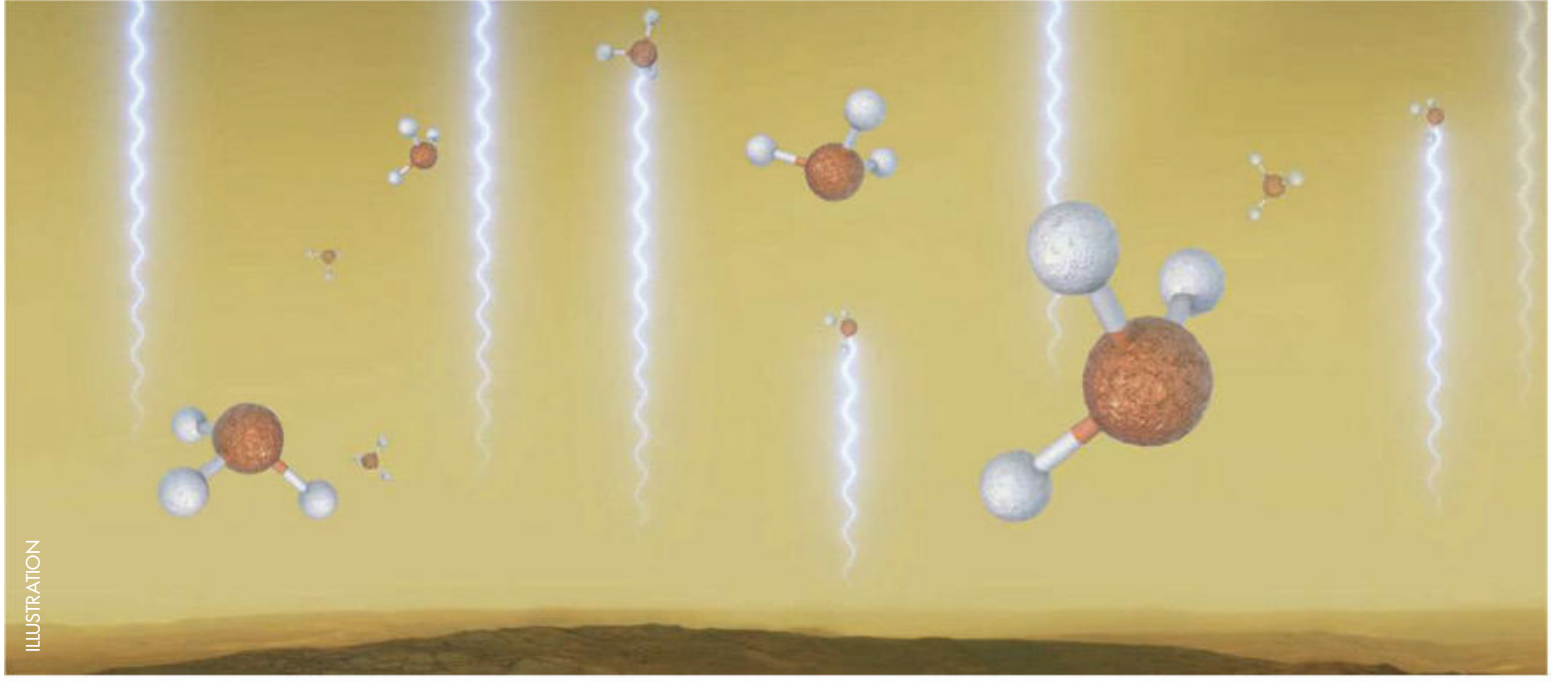
Greaves first tracked down the molecule in 2017 using the JCMT (James Clerk Maxwell Telescope) in Hawaii, before reconfirming the discovery with the much more powerful ALMA (Atacama Large Millimeter /Submillimeter Array) telescope three years later.

"Given that we did this with two independent observatories, we can say with very high confidence we have detected phosphine molecules on Venus," says Greaves. "The phosphine is there, but it is very scarce – about 20 molecules for every billion other molecules."

The discovery took some persistence on Greaves's part, as her initial request for telescope time was rejected on three occasions, as it was thought the chances of finding phosphine-producing life on Venus were ridiculously remote. With temperatures high enough to melt lead, clouds filled with sulphuric acid and surface pressures the equivalent of being under 1km of water, Venus is more often considered a hellscape than habitable.

"But it's thought that earlier in Venus's history the surface was much cooler and wetter, and life could possibly have originated there," says Greaves. "Some of these microorganisms might have been able to evolve upwards into the clouds. Now, it's very acidic there, but around 50-60km up the pressure is like Earth and the temperature is a nice 30°C, so it's been hypothesised that this is a living habitat today."

▲ Earth-like quality: high in the atmosphere of Venus, 50–60km up, the pressure and temperature are more comparable to our planet



▲ **An artist's impression of phosphine molecules floating in windblown Venusian clouds at altitudes of 55–80km**

To investigate if there are any non-biological ways phosphine might form on Venus, William Bains from MIT (the Massachusetts Institute of Technology) examined the chemistry of the atmosphere, seeing if sunlight could be driving a complex network of interactions to create phosphine. "The bottom line is that the rate through that network is too slow, by factors of hundreds of thousands to millions, to explain the 20 parts per billion of phosphine that Jane [Greaves] has observed," says Bains.

A sign of life?

The team also looked into other chemical reactions, modelling every conceivable interaction between the components of Venus's atmosphere, as well as geological reactions in the rock of the planet's surface. Even lightning and meteors were considered, but every method produced phosphine at rates a million times slower than needed to match the observations.

"There are two explanations," says Bains. "The first is that there is some completely unknown and exotic, therefore exciting, chemistry going on in the clouds of Venus that no one has speculated on before. Or – and this is the more exciting one – the second is that the phosphine is being produced by life."

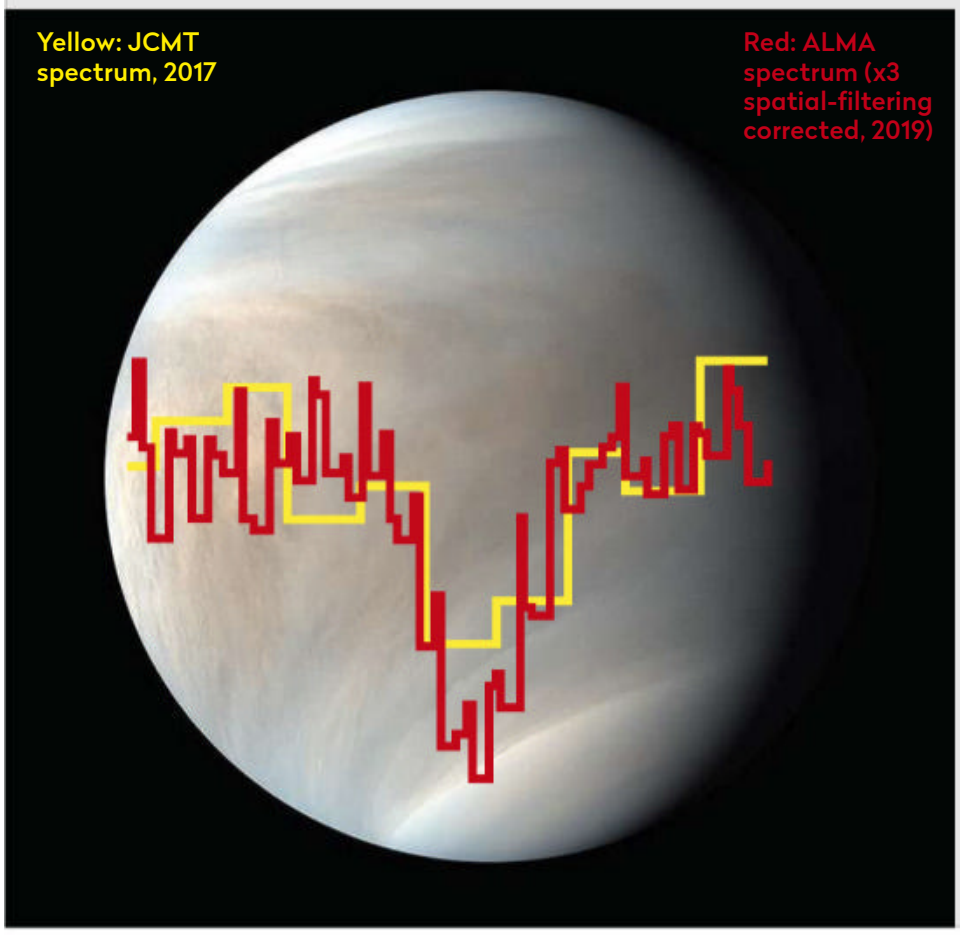
Astronomers are now scrabbling to get telescope time to pin down exactly where and how much of the gas there is on Venus. They also hope that the discovery will motivate new space missions to Venus's atmosphere to measure the gas directly. The last time humanity delved into the planet's clouds was in 1985, when the Soviet Vega missions explored Venus by balloon. Currently, there are several atmospheric missions to the planet under review, such as NASA's DAVINCI and India's Shukrayaan-1. With the potential glory of being the first people to discover life outside Earth, it probably won't be too long before we return to the skies above our nearest neighbour.

www.eaobservatory.org/jcmt

▸ Read more about the Venus discovery in our feature on page 29 and 'Inside The Sky at Night' on page 18

How do you find phosphine?

The chemical was found thanks to its unique absorption fingerprint



Phosphine absorbs light at a very specific wavelength that is unique to the chemical. Because of this, Greaves's team were able to hunt for phosphine by looking at how bright the planet was at a range of wavelengths around this value. At first, they did this using the relatively low resolution JCMT (shown in yellow) before re-observing Venus with the more precise ALMA (shown in red). Both telescopes found a dip in brightness created by something in the atmosphere absorbing light at a specific wavelength, one that perfectly corresponded to the wavelength phosphine absorbs at. They had made a positive detection.

◂ Taking a dip: the Venus spectra from the ALMA and JCMT telescopes showed light absorption by phosphine

Comment

by Chris Lintott

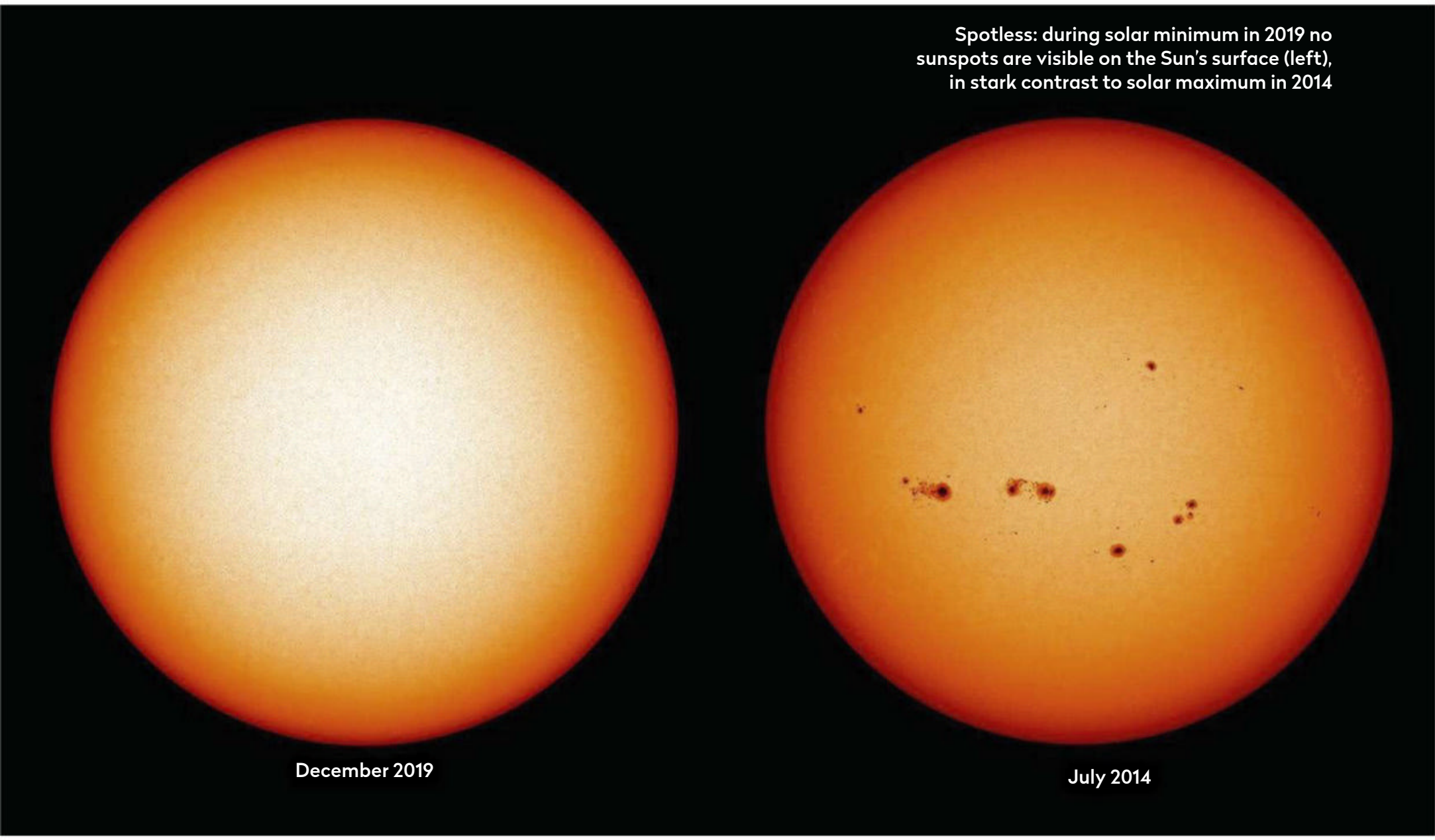
Geologists, chemists and observational astronomers around the world have not been slow to weigh in on this exciting discovery. The most interesting result comes from digging out data from a mission that visited Venus in 1978.

The Pioneer mission sent probes into the planet's thick atmosphere, measuring the mass of molecules as it descended through the clouds. One of the detections has the right mass to be phosphine, at a similar abundance to that detected by Greaves's team.

Other data from the mission might help us understand if lifeless chemistry is behind a presence of phosphine; the data seems to reveal the presence of other molecules that might play a role in any set of chemical reactions that could account for what's seen.

There's lots of work to do to understand Venus, but if even archive data is this exciting it's clear we're in for an exciting ride.

Chris Lintott co-presents *The Sky at Night*



Spotless: during solar minimum in 2019 no sunspots are visible on the Sun's surface (left), in stark contrast to solar maximum in 2014

NASA/SDO/JOY NG, NASA'S GODDARD SPACE FLIGHT CENTER, NASA, ESA/ROSETTA/NAVCAM

New solar cycle begins

Sunspot activity is likely to remain below average for some time to come

Solar Cycle 25 has officially begun. After a year and a half with barely any sunspots, a group of astronomers, known as the Solar Cycle 25 Prediction Panel, have recently announced that the Sun's activity has been steadily climbing since December 2019.

"We keep a detailed record of the few tiny sunspots that mark the onset and rise of the new cycle," says Frédéric Clette, part of the panel and head of the World Data Centre for the Sunspot Index and Long-term Solar Observations (SILSO). "These are the diminutive heralds of future giant solar fireworks. It is only by tracking the general trend over many months that we can determine the tipping point between two cycles."

Though astronomers track the cycle on the Sun's surface, its origin stems from the motion of plasma deep within our star. This movement creates its magnetic field, but as the Sun spins it churns up this plasma. Over time, this motion drags the magnetic field lines away from the poles towards the equator; eventually the field lines straighten out, but with their direction reversed. This flip takes around 11 years to occur and is the physical basis of the solar cycle.

If the sunspots continue to follow their current trend, the panel predict the peak of solar activity in Cycle 25 will occur some time between November 2024 and March 2026. At this time not only will there be more sunspots, but more solar flares and mass ejections from the Sun too, which could mean bigger and brighter auroral displays here on Earth.

It's important to know when such solar outbursts will be particularly intense as their radiation can damage space equipment, as well as satellites and the communications and location services that rely on them. For NASA, there is the added concern that peak activity will fall during the timeframe it hopes to fly astronauts to the Moon, beyond the protective shield of Earth's magnetosphere, with the Artemis program.

The panel expect this cycle to be relatively weak, as solar activity has been trending downwards since the 1980s, but this might not be enough to be risk free.

"Just because it's a below-average cycle, it doesn't mean there is no risk of extreme space weather," says Doug Biesecker, co-chair of the panel and a solar physicist at NOAA's Space Weather Prediction Center. "The Sun's impact on our daily lives is real and is there."

www.sidc.be/silso

WD 1856 b, a potential Jupiter-sized planet, orbits a smaller white dwarf

Planet survived star's death

The world is seven times larger than the white dwarf star it orbits

A giant planet around a white dwarf could have survived the star's death throes, according to the latest observations with the Transiting Exoplanet Survey Satellite (TESS).

A white dwarf is the remnant left behind after a Sun-like star runs out of fuel, becomes a red giant and then loses its outer layers. "The white dwarf creation process destroys nearby planets, and anything that later gets too close is usually torn apart by its immense gravity," says Andrew Vanderburg of the University of Texas, Austin, who led the work.

The planet, WD 1856 b, is so close that it orbits in only 34 hours, but it is likely to have been further out when the star was in its red giant phase.

"We've seen that planets could scatter inward, too, but this appears to be the first time we've seen a planet that made the whole journey intact," says Vanderburg.

exoplanets.nasa.gov/tess

Artemis's return to the Moon mapped out

NASA's planned return to the Moon is scheduled to arrive on the lunar surface by 2024. The agency recently released its timeline for the Artemis program, which includes landing the first woman on the Moon, with the first stage, Artemis I, due to fly in 2021.

The first flight will be an uncrewed test, using the Space Launch System to send the Orion Multi Purpose Crew Vehicle to the Moon and back to confirm both are safe for humans. Artemis II will then repeat the flight in 2023 with astronauts onboard.

If these go to plan, NASA will launch Artemis III in 2024, which will send a lander down to the lunar South Pole. Subsequent missions will use a space station NASA plans on building in orbit around the Moon, known as the Lunar Gateway, but it may not be ready in time for Artemis III.

"We're going back to the Moon for scientific discovery, economic benefits, and to inspire a new a generation of explorers," says Jim Bridenstine, NASA's administrator. "As we build up a sustainable presence, we're also building momentum toward those first human steps on the Red Planet."

www.nasa.gov

Back to the Moon: NASA's Orion spacecraft is an important part of its Artemis program

NEWS IN BRIEF

Comet aurora

Ultraviolet aurora have been seen dancing around comet 67P/Churyumov-Gerasimenko – the first time such a light show has been seen around a celestial object other than a planet or moon. Recently analysed images taken by the Rosetta spacecraft show the solar wind interacting with the comet's coma to produce the aurora.

Dark skies in NI

The Dark Sky Observatory and Visitor Centre in the Davagh Forest, Mid Ulster is finally due to open on 17 October, after being delayed due to the COVID-19 pandemic. The forest is Northern Ireland's first accredited International Dark Sky Park.

A Pi-fect planet

A 'pi-planet' has been discovered zipping around its host star once every 3.14 days. The planet has a radius about 0.95 times the size of Earth's, but it isn't thought to be habitable as its tight orbit means the surface temperature is expected to be around 180°C – hot enough to bake an actual pie.

NEWS IN BRIEF

Out of alignment

The Solar System could be aligned along more than just the ecliptic (the plane that the planets orbit in). A recent look at the orbits of long period comets revealed that many of them appear to line up along a newly discovered 'empty ecliptic', which is offset by around 120°.

Nobel prize for black holes

The 2020 Nobel Prize in physics has been awarded to three scientists investigating black holes. The award will be shared between mathematician Roger Penrose for his theoretical work on how they form, and astronomers Andrea Ghez and Reinhard Genzel for their discovery of the black hole at the heart of the Milky Way.

China's reusable spaceplane

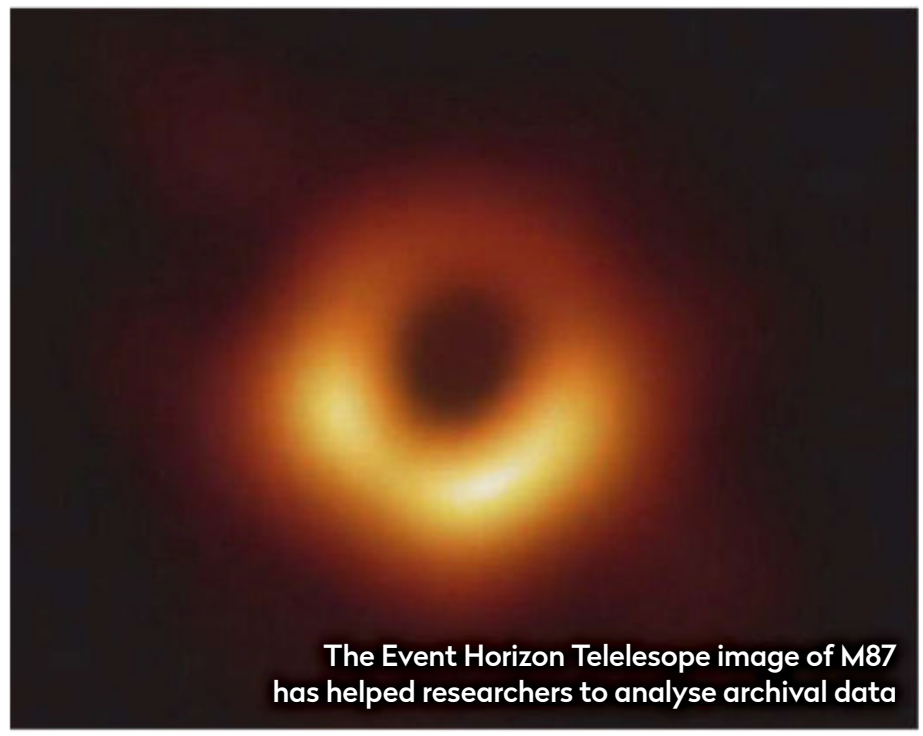
China successfully launched a prototype reusable spacecraft on 4 September. It remained in low-Earth orbit for two days before landing back on Earth. However, images or details about the spacecraft have not been officially released, leading many to question its potential purpose.

RWARNICK/ISTOCK/GETTY IMAGES, EHT COLLABORATION, NASA/JPL-CALTECH/MSSS, NASA/JPL-CALTECH/UNIVERSITY OF ARIZONA/LPG/CNRS/UNIVERSITY OF NANTES/SPACE SCIENCE INSTITUTE

BULLETIN

M87's glittering black heart

Astronomers have tracked a black hole shimmering for over a decade



The Event Horizon Telelesope image of M87 has helped researchers to analyse archival data

The black hole at the heart of galaxy M87 appears to be glittering. The galaxy first made headlines in 2019 when a network of telescopes known as the Event Horizon Telescope (EHT) imaged the shadow of its central black hole. Armed with the EHT image to guide them, astronomers have gone back over the data taken by prototype networks that preceded the EHT to extract earlier images of the black hole. In doing so, they created a timeline of its appearance over the last decade. The analysis showed that while the ring stays the same size, its brightest point dances around the edge, giving it a shimmering appearance.

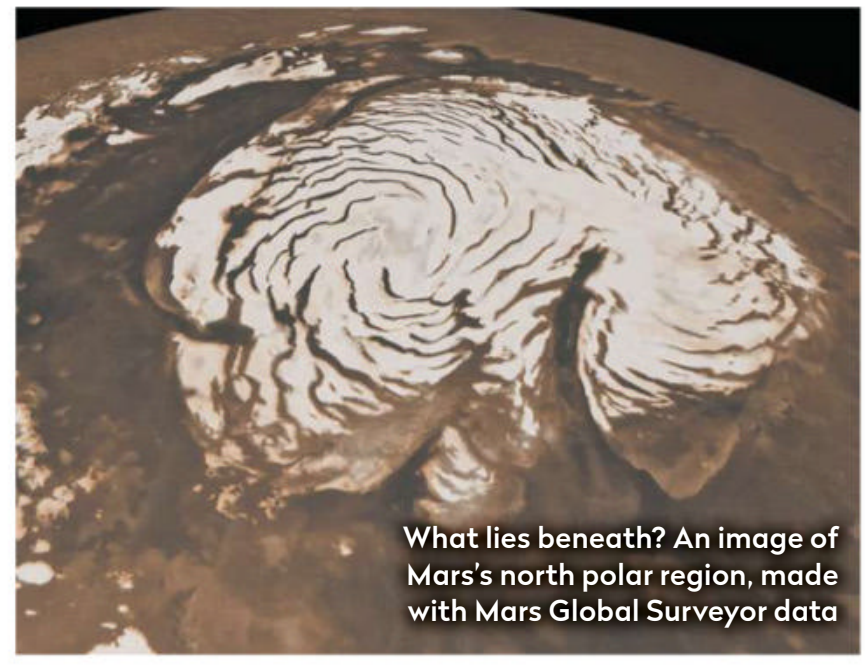
"Studying the region will be crucial for a better understanding of how black holes accrete matter and launch relativistic jets," says Thomas Krichbaum from the Max Planck Institute for Radio Astronomy.

eventhorizontelescope.org

Potential Martian lake and companion ponds

Water lakes could be lying beneath Mars's ice caps, according to the latest radar analysis of the planet.

Hints of a huge lake 1.5km underneath the Red Planet's poles were first uncovered back in 2018. The find prompted Roberto Orosei from the National Institute for Astrophysics in Bologna, Italy, and his team to re-examine data of the region taken by ESA's Mars Express orbiter from 2010 to 2019. These revealed several reflective, flat areas beneath the surface that confirm the earlier find, with the addition of three smaller ponds.

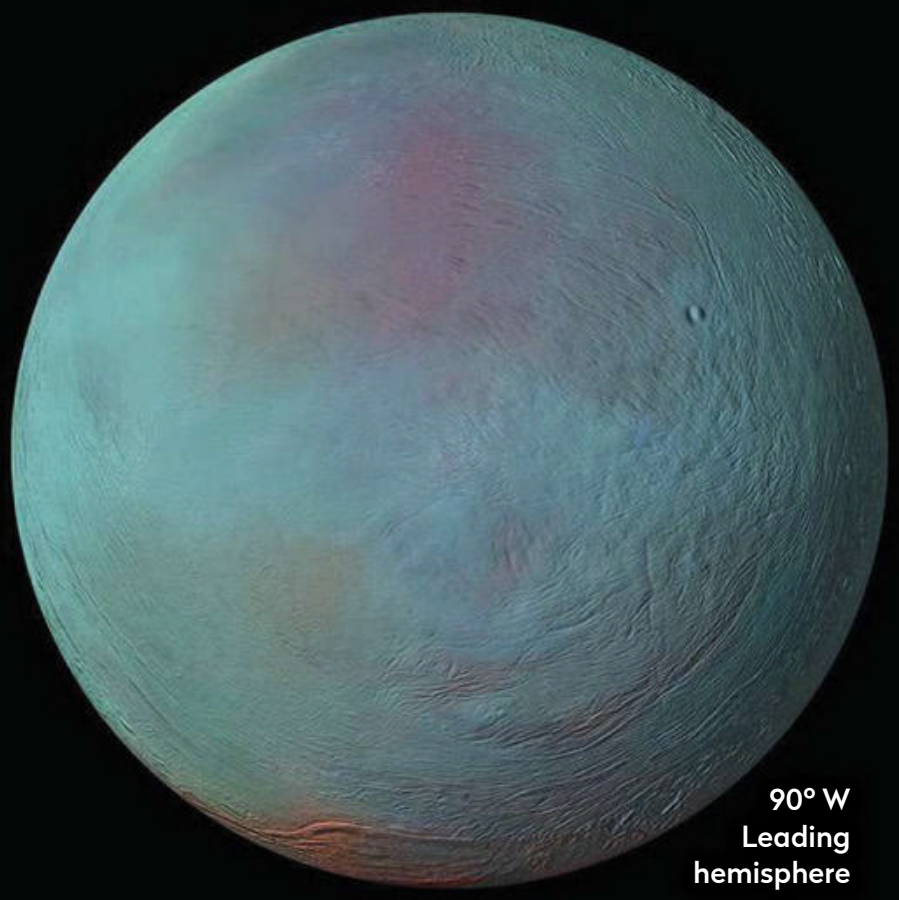


What lies beneath? An image of Mars's north polar region, made with Mars Global Surveyor data

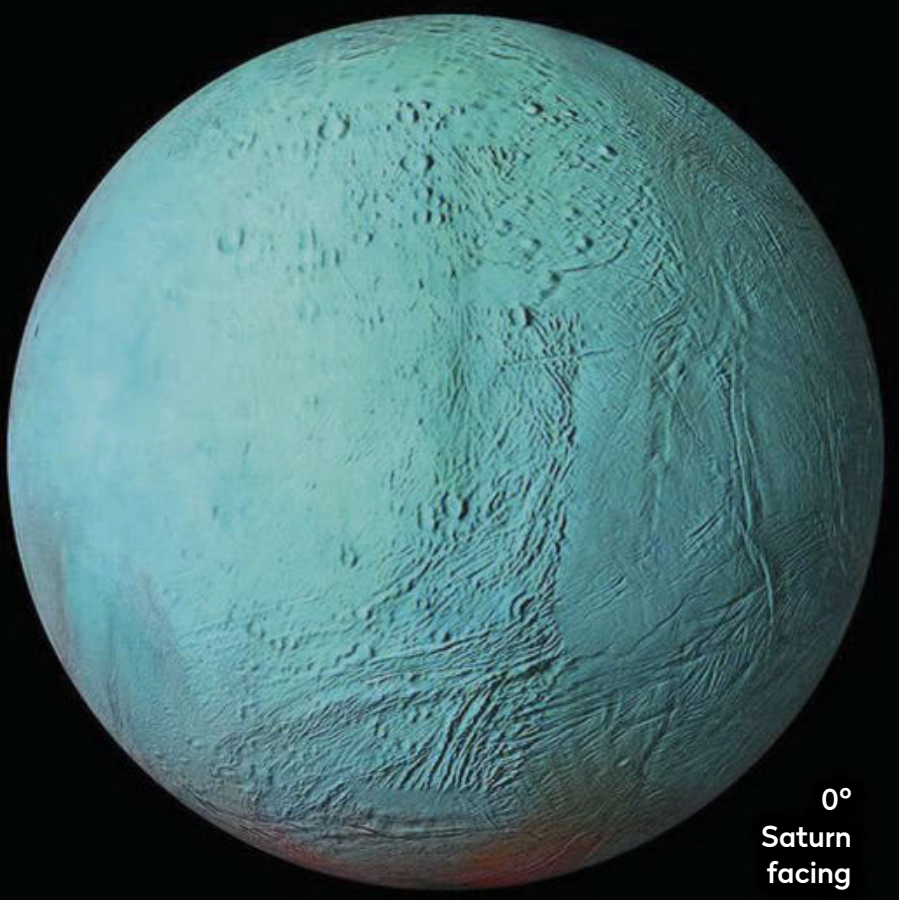
Whether or not the areas are actually liquid, however, has split planetary scientists. While similar observations on Earth have revealed subglacial lakes, these would need to somehow stay liquid at temperatures of –70°C. This could be possible if they were extremely salty.

"We don't know exactly what is in this water," says Orosei. "We don't know the concentration of salts, which could be deadly to life. [Alternatively] these lakes could have been providing a Noah's Ark that could have allowed life to survive even in present conditions."

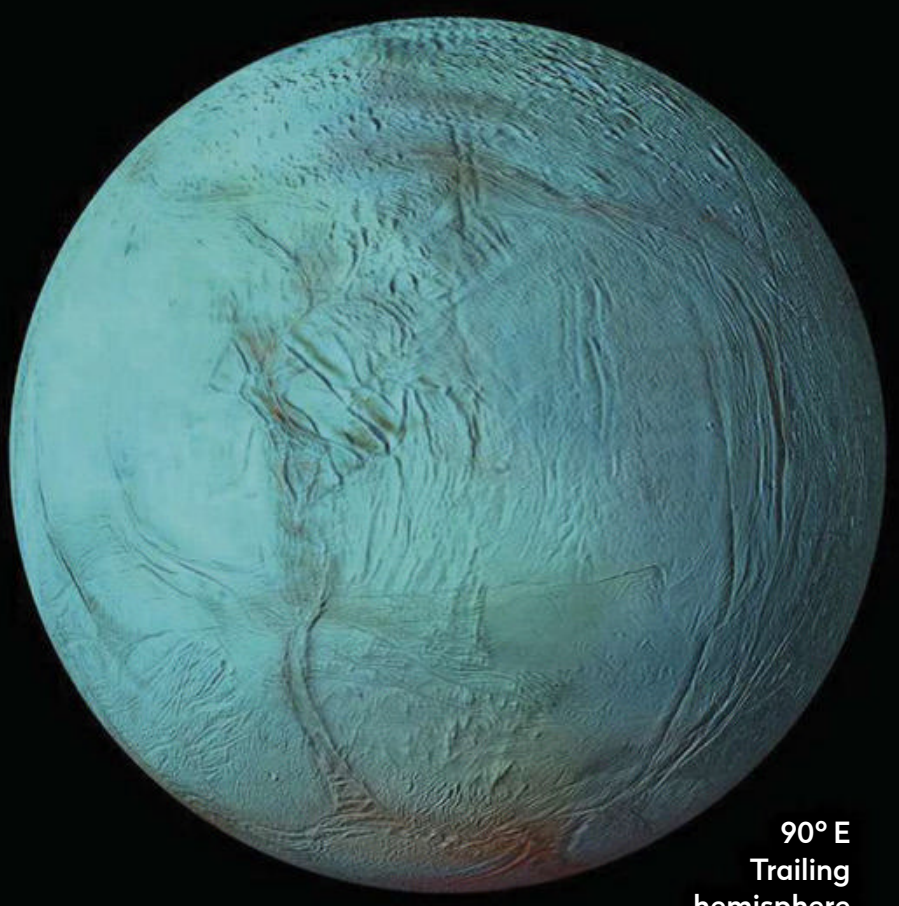
www.esa.int



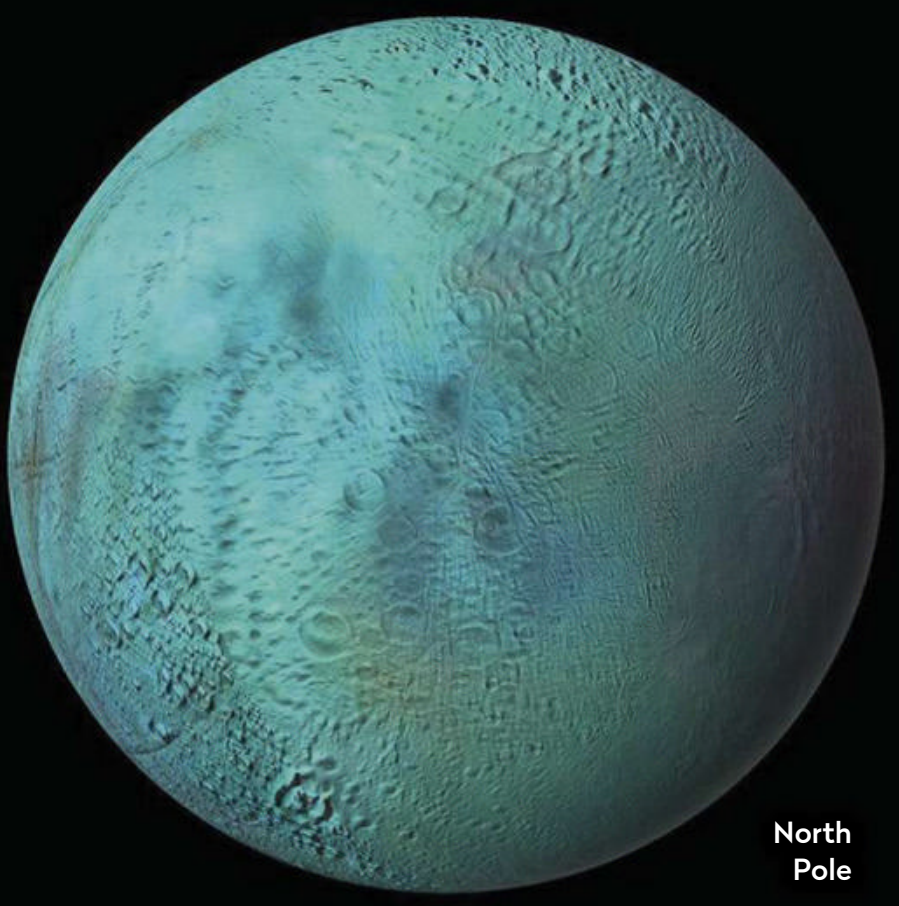
90° W
Leading
hemisphere



0°
Saturn
facing



90° E
Trailing
hemisphere

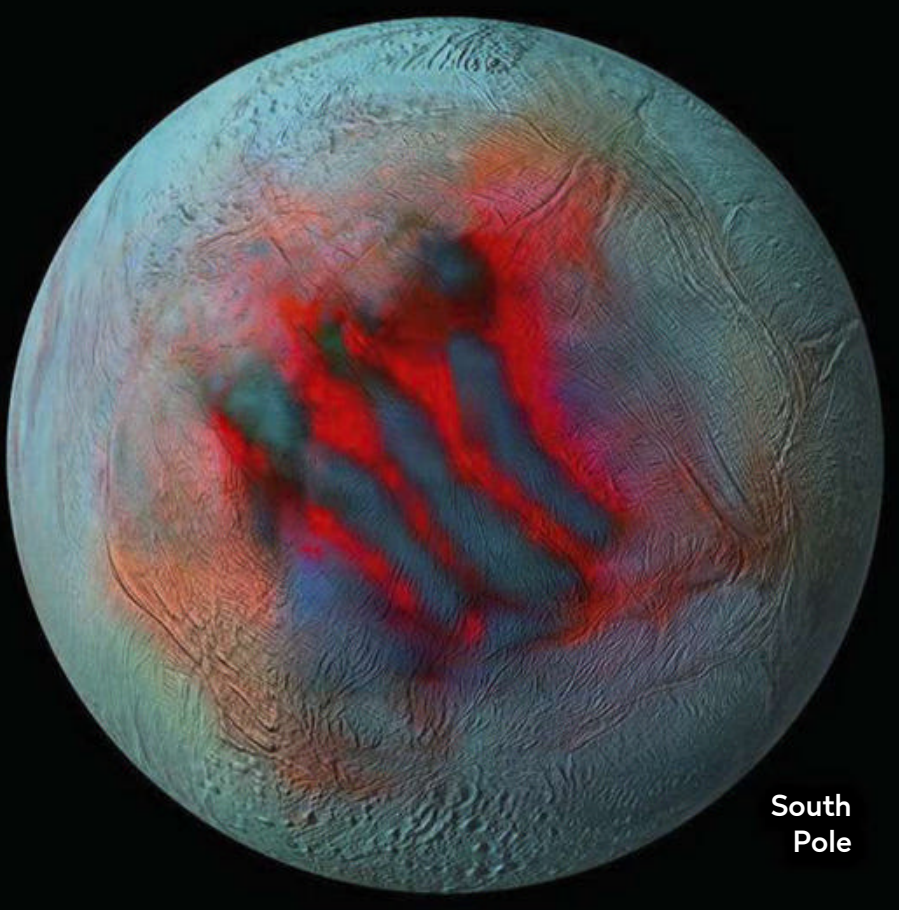


North
Pole

Icy Enceladus's fresh faces

Enceladus, one of Saturn's icy moons, appears to have a youthful glow around its northern pole, according to newly processed images from NASA's Cassini spacecraft.

The spacecraft's infrared cameras revealed areas of fresh ice (shown in red) across the moon's surface. While it's no surprise to find the south pole is resurfaced – the area is home to several cracks, known as 'tiger stripes', where water sprays up from below the surface – the images also revealed subtler patches of new ice in the northern hemisphere. "Thanks to these infrared eyes, you can go back in time and say that one large region in the northern hemisphere also appears young and was probably active not that long ago, in geologic timelines," says Gabriel Tobie, from the University of Nantes, who helped write the paper.
www.jpl.nasa/gov



South
Pole

Our experts examine the hottest new research

CUTTING EDGE

ILLUSTRATION

Is there a planet orbiting a binary star system that is hopping between orbits?

Exoplanets dancing around double stars

What weird and wonderful orbits might be possible around binary stars?

Although the vast majority of extrasolar planets discovered so far are around singleton suns, many of the stars in our Galaxy are part of binary or multiple systems. It's much trickier to detect exoplanets in multiple systems (for example, the other bound stars completely swamp any sign of a companion planet), but there's no reason to suppose that they're not also pretty common.

There are three different kinds of orbit that a planet in a binary star system can remain stable within. The first is a 'satellite-type' or S-type internal orbit, whereby the planet circles one of the two stars. Astronomers have discovered around 50 confirmed exoplanets on S-type orbits, and in fact, we know of two systems where both of the binary stars harbour their own planet.

Or the planet could have a wide, circumbinary orbit around both stars in the middle – what's known as a 'planet-type' or P-type external orbit. It's even theoretically possible for a planet to be held within the L4 or L5 Lagrangian equilibrium point, co-orbiting with the smaller star around the larger star, which is comparable to how the Trojan asteroids sit within Jupiter's Lagrange points in our Solar System. This third possibility is a special case and is calculated to only be stable when the smaller star is less than four per cent the mass of the larger star – a small red dwarf orbiting a blue and white A-class companion for instance.

Exactly what orbital setups of the binary stars and planet create stable systems, though? Roberto Capuzzo-Dolcetta at the University of Rome, and Giovanni De Cesare, at the Astrophysics and Space Science Observatory of Bologna have been running computer simulations to find out. They modelled more than 10,000 possible systems with different initial conditions – varying the combinations of stellar masses, orbital distance, eccentricity and so on – and followed the evolving dynamics of the paths of the stars and planet over a long time period (a billion years or more). They considered the system to be unstable if the planet was lost: either by falling into either of the two stars, or by being gravitationally ejected from the system altogether. The authors also created a real-time orbital simulator that is available at **https://giovixo.github.io/exoplanets/index.html**.

Capuzzo-Dolcetta and De Cesare found, unsurprisingly, that if the configuration was unstable the planet was much more likely to collide into the star with the greater mass (and thus the one with the dominant gravitational effect within the system) than the smaller one. They also determined the edge of the instability zone – how far away from the larger star an S-type orbiting planet was still stable – and found, for example, that if the companion star were 10 per cent of the larger's mass the planet could survive on a wide orbit that reached almost half way across the system without being torn away.

"Could a planet be nudged out of an S-type orbit around one star and into a stable P-type orbit around both stars?"

But Capuzzo-Dolcetta and De Cesare also noticed something very interesting. In many of the instances where the planet was torn from its stable orbit around one star before being slung completely out of the system, it first moved on an outer orbit for a while. This got them thinking; could a planet be nudged out of an S-type orbit around one star and into a stable P-type circumbinary path around both (or visa versa)? When they ran the numbers they discovered that such an eventuality, although not very probable, was indeed possible. The finding raises the intriguing chance that somewhere out there right now is a planet hopping orbits.

Prof Lewis Dartnell is an astrobiologist at the University of Westminster

Lewis Dartnell was reading... *Stability of Planetary Motion in Binary Star Systems* by Roberto Capuzzo-Dolcetta, Giovanni De Cesare and Alessio Marino. **Read it online at: https://arxiv.org/abs/2007.05412**

RASTAN/ISTOCK/GETTY IMAGES, DRACO-ZLAT/GETTY IMAGES

Black hole jets could be hiding in plain sight

A new discovery could explain how active and calm galaxies co-habit the same regions

Prof Chris Lintott is an astrophysicist and co-presenter on *The Sky at Night*

You might assume it would be difficult to confuse a galaxy and a star, and yet that's the story of 'BL Lac' objects, the engimas at the heart of this month's paper. Named after the first example that was found in the otherwise obscure constellation of Lacerta, these objects show rapid and significant changes in brightness, and were originally thought to be a rare form of variable star. We now know that their light comes not from a star at all, but from the centres of active galaxies, as material falls onto the supermassive black holes that lurk there.

When enough material falls towards the centre of a galaxy, first an accretion disc forms – as seen in those wonderful images from the Event Horizon Telescope, released last year – and then some can be expelled in a rapidly moving jet. In the case of BL Lac objects, conditions are so extreme that the jets sometimes seem (thanks to a quirk of geometry) to be moving faster than the speed of light.

The strange behaviour of BL Lac might be explained if we're staring down the barrel of the jet itself. The rapid changes in brightness seen in both visible light and at radio wavelengths are then explained by the behaviour of material in the jet, rather than around the black hole itself. Testing this idea is hard, though, and the authors of this month's paper have had a good idea.

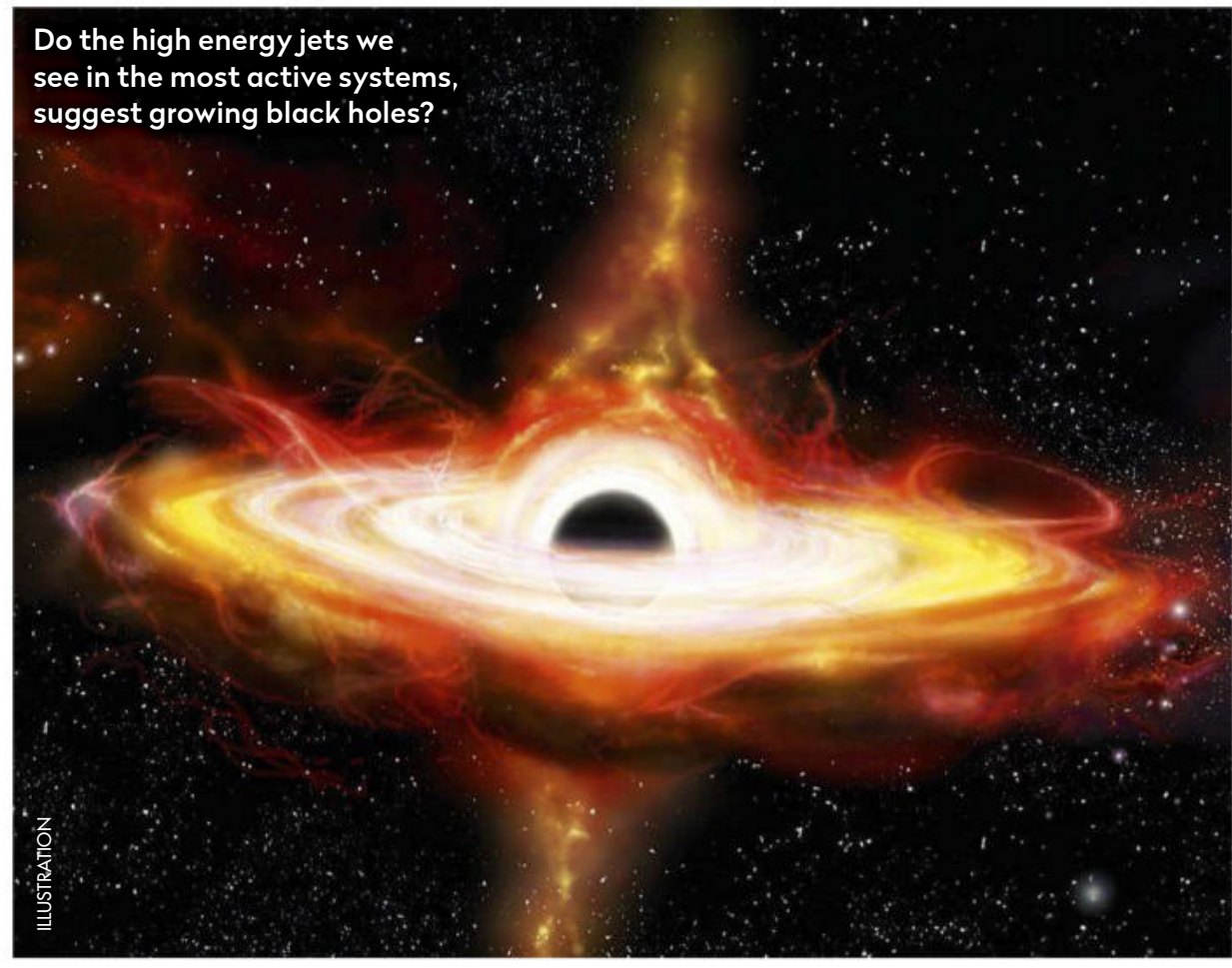
Assembling a collection of massive elliptical galaxies which host BL Lac objects, they look at their environments, and whether they're found in dense clusters of galaxies, the middle of empty voids, or somewhere in between. This is difficult to do precisely, but a good estimate can be made just by counting a system's neighbours – after all, if you have more neighbours you live in a more crowded area!

Once the count is complete, comparisons can be made with other sorts of objects – in this case, with other types of active galaxies. If we get a BL Lac when we stare down the jet, there should be a whole population of galaxies out there which are the same, except that the jet points in another direction. Those other systems should be found in the same kind of environment.

> ***"BL Lac objects show rapid and significant changes in brightness, and were originally thought to be a rare form of variable star"***

The prime candidate is a type of active galaxy called an FR I, but the authors show convincingly that these live in more crowded environments, and so they can't be the 'hidden' BL Lacs. However, the BL Lacs do match another population in environment: they live in the same places in the Universe as a type of galaxy called an FR 0. These are essentially bright points of radio emission. This result is itself a mystery – why should the most spectacular examples of active galaxies share an environment with these relatively quiet systems?

One answer, proposed by the team, is that the high energy jets we see in the most active systems are actually a ubiquitous feature of galaxies with growing black holes. If the jet points towards us, we get a BL Lac, and if it doesn't we see a nice, quiet system. If jets really are this common, we'll need to explain how such jets form – and can expect a jet to have been a feature of our own Milky Way's past.



Do the high energy jets we see in the most active systems, suggest growing black holes?

ILLUSTRATION

Chris Lintott was reading... *Dragon's Lair: on the large-scale environment of BL Lac objects* by F Massaro et al.
Read it online at: https://arxiv.org/abs/2009.03318

The Sky at Night TV show, past, present and future

INSIDE THE SKY AT NIGHT

The Sky at Night's schedule is usually only moved for major space missions, but a possibility of life on Venus proved an important exception. **Chris Lintott** recalls how the show reacted to the news

▲ Clockwise from top left: Chris Lintott meets Jane Greaves from Cardiff University to discuss her findings about traces of phosphine in the atmosphere of Venus; chemist William Bains gives a musical slant to Venusian life; Emily Drabek-Maunder, from the Royal Observatory Greenwich, discusses the project's origins; Jane Greaves shares the data she used to trace the presence of phosphine

BBC X 4, JEREMY SUTTON-HIBBERT/ALAMY STOCK PHOTO, ESO/M. KORNMESSER

Have you imagined where you'd be when you hear that aliens have turned up? I heard about the amazing discovery featured in this month's programme while sitting in my kitchen, speaking to an old friend of the programme, Chris North, on the phone.

Chris was calling to tell me that a team led by his colleague Jane Greaves in Cardiff had found what they thought was a biosignature – a sign of life – in the atmosphere of Venus. What he actually said to me was, "Can you speak Venusian?" It's the title of one of Patrick Moore's books covering 'independent thought' – UFOs, a vicar who thinks the Sun is cold, that sort of thing.

It quickly became clear that, unlike the man who in one archive episode explained to Patrick that Jesus came from Venus, this story was credible. But it was due to be released the day after *The Sky at Night* was to be broadcast. Because of the importance of the discovery, we quickly moved the show, something we normally only do for major space missions. And so producer Toby, assistant producer Angel and I found ourselves wandering the corridors of a nearly deserted Cardiff physics department, chatting about life on Venus and the wonders of phospine.

Persistence pays off

I've known Jane a long time and it was so exciting to see her pride in her team and their discovery, and I marvel at the perseverance she showed in pursuing a project through numerous rejections by observatories and referees. But it was still bizarre to be sitting in someone's office and asking – on camera, in a matter of fact tone – "Have you found life?" Jane's answer was that she was worried about the sulphuric acid content of the clouds, but it was clear that the idea that this might be life was the thing which had pushed her through the years of hard work.

Prof Chris Lintott is an astrophysicist and co-presenter on *The Sky at Night*

We also talked to chemist William Bains, who volunteered to bring his guitar to sing us a song about Venusian life, and melted all sorts of things, including bread, with concentrated sulphuric acid. Meanwile, Emily Drabek-Maunder from the Royal Observatory Greenwich, told us about the project's origins and then, after a long day and the cameras put away, Chris North and I sat with takeaway beer on the grass outside Cardiff Castle, and let our imaginations run.

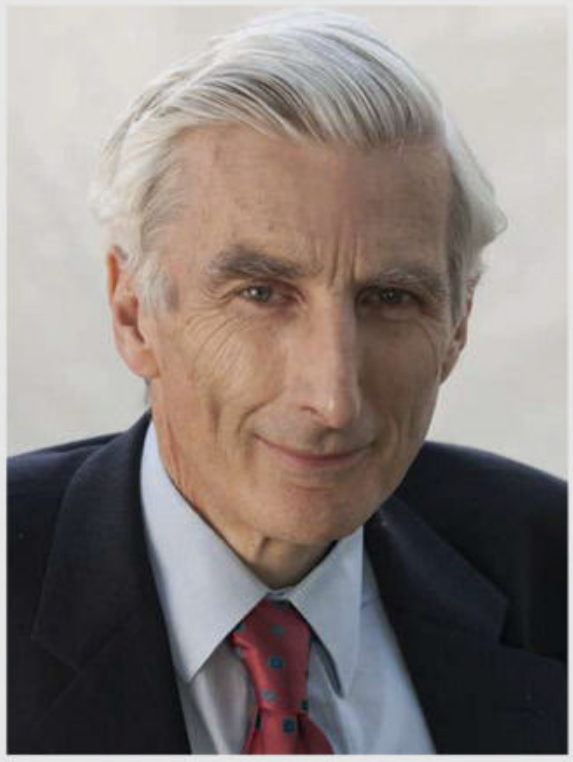
Could the detection of phosphine mean sending balloons to sail the high clouds of Venus's atmosphere, looking for life? Could this life be the remnant of some grand old Venusian civilization, reduced to clinging on among the clouds? If life exists on Venus, shouldn't it be everywhere? Or – and I confess the beer made us concentrate rather less on this possibility – could there be some unknown chemistry at work, which the team's models haven't accounted for.

A discovery like this is exciting not because it solves a problem, but because it raises a million questions. That's why it's fun, and why I'm so proud that *The Sky at Night* was able to report on a surprising and fascinating new result.

▸ Read more about the Venus discovery in our feature on page 29 and in 'Bulletin' on page 10

We need you!

Have your questions answered on the show



◂ Astronomer Royal: Sir Martin Rees will be featured on the special episode of *The Sky at Night* in December

Do you have a question you'd like put to one of the top astronomers in the country?

The December episode of *The Sky at Night* will be a one-hour special looking at the major advances, achievements and discoveries in astronomy over the past decade. It will also be looking forward to the next 10 years and discuss the challenges, frontiers and opportunities that lie ahead.

The programme will feature interviews with some of the leading astronomers in the country, including the Astronomer Royal, Sir Martin Rees (left).

The Sky at Night is offering viewers the chance to have their question put to one of the guests on the programme.

Your question could relate to any area of astronomy, looking back over the past decade, or forward into the future – whether it's the exploration of our own Solar System, hunting for signals from the edge of the Universe or anything in between.

If you would like your question to be considered, please send it to: **skyatnightqt@bbc.co.uk**

Please include your name, address and contact number.

Beyond Venus

Following the news about possible signs of microbial life in the clouds of Venus, the team report on the discovery from the Royal Observatory Greenwich. Chris and Maggie find out about further research and look into the wider search for life in the Solar System, focusing on Mars, Titan, Enceladus and Europa, as well as biological signatures on planets orbiting distant stars.

BBC Four, **8 November**, 10pm (first repeat BBC Four, **12 November,** 7:30pm)
Check www.bbc.co.uk/skyatnight for more up-to-date information

▲ After Venus, could a similar discovery be made on a planet beyond our Solar System?

INTERACTIVE

Email us at **inbox@skyatnightmagazine.com**

This month's top prize: four Philip's titles

PHILIP'S The 'Message of the Month' writer will receive a bundle of four top titles courtesy of astronomy publisher Philip's: Ian Ridpath and Wil Tirion's *Star Chart*, Robin Scagell's *Guide to the Northern Constellations*, Heather Couper and Nigel Henbest's *2021 Stargazing,* and a planisphere for the night skies as they appear at latitude 51.5° north.

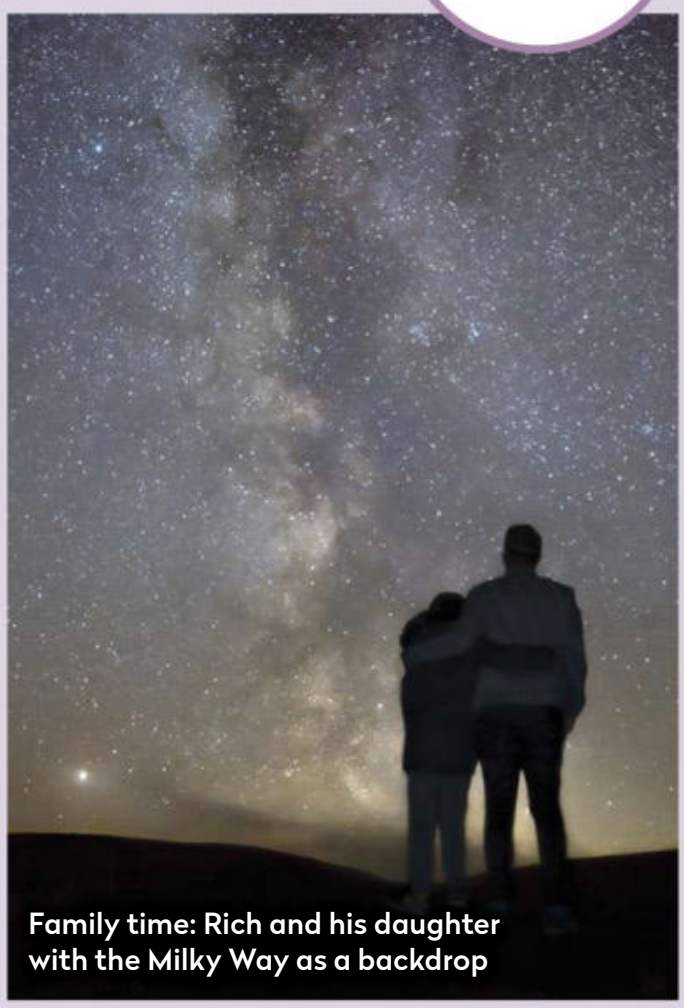
Winner's details will be passed on to Octopus Publishing to fulfil the prize

A night under the stars

My eight-year-old girl had a tough week. She had school in the morning and after, we drove for two hours to a Bortle 3 area to look at the cosmos. It was so dark, there was no light except the Universe above us! She described it as a "once in a lifetime experience". Here's a photo of us taken with a Nikon D5100 DSLR camera and Nikkor 24mm f/2.8 lens, with a 10-second exposure at ISO 6400. Its two panels are each composed of 10 exposures stacked in AutoStakkert! and then stitched together in Photoshop.
Rich Addis, via email

A truly touching message and photo, Rich! A dark night sky and the glittering stars of our Galaxy are sometimes just the thing to put things back in perspective. ***– Ed.***

MESSAGE OF THE MONTH


Family time: Rich and his daughter with the Milky Way as a backdrop

Tweet

Allan D
@aduffy65 • Sep 26
Planet #Mars shining bright last night #astronomy #astrophotography @skyatnightmag #ThePhotoHour 4" #Skywatcher #telescope

Inorganic theory

The recent discovery of phosphine in the Venusian atmosphere, published in *Nature Astronomy*[1], prompted us to suggest an inorganic hypothesis for the origin of this gas. Galactic phosphorus exists as mixed iron-nickel phosphides, which are secondary phases in iron-nickel meteorites. These are credited with supplying much of Earth's phosphorus[2], although most of the discussion of that is framed in terms of phosphate. In fact, metal phosphides evolve into phosphine when they meet water or aqueous solutions, especially those of strong acids[3], which are present on Venus.

It seems plausible that there is a kind of inorganic phosphorus cycle taking place on Venus. Whether this would stand up to quantitative scrutiny remains to be seen, but we thought it was well worth mentioning.

1. Greaves, Jane S., et al., "Phosphine gas in the cloud decks of Venus", Nature Astronomy (2020): https://doi.org/10.1038/s41550-020-1174-4
2. https://en.wikipedia.org/wiki/Schreibersite
3. Tanaka, Tatsuhiko, et al. "Simultaneous determination of phosphorus, sulfur and arsenic in steel by hydride generation and gas chromatography", Analytical Sciences (1996): 12, 77-80. https://doi.org/10.2116/analsci.12.77
Roger C Newman and Touraj Ghaznavi, Toronto

Inspired by stars

In March 2020 I was doing my rounds as a security guard and began to take notice of some of the constellations. They had never interested me before as I'd always thought of them as 'just stars', but this time when I got back to the office I did

some digging. What I found would change my life: the different types of stars, nebulae, star life-cycles, planets and so much more inspired me to learn. I never thought I'd ever want to pick a book up again after my GCSEs, but here I am doing online courses and looking at going back to do my A levels and then go to university.

Astronomy has given me the inspiration to re-educate myself and one day I hope to volunteer at an observatory or planetarium and show others the majesty of the Universe. I'm nearly 30 years old and had given up on prospects of a career, but discovering the stars has ignited the ambition in me.

Jon Adams, via email

Moon views

While confined to the house and back garden I managed to snap the Moon with my iPhone and 'spotter scope' for birdwatching (see picture, top right). Then I saw your photo of lunar craters Theophilus, Cyrillus and Catharina (May 2020 issue, 'Moonwatch') so I had a go at some machine embroidery from it (lower image, below) for the Royal Astronomical Society's bicentennial quilt.

Nicky Robertson, via email ▸

ON FACEBOOK

WE ASKED: What do you make of the recent discovery of evidence of microbial life on Venus?

Danny Castro When you consider that astronomers have discovered planets around just about every single star they've looked at closely, that our Galaxy alone has something like 150–250 billion stars, and that it is just one very average galaxy out of 100 billion estimated to be out there in the Universe, each with its own stars and planets, I think it would be a pretty big waste of space if we were the only life in the Universe. I hope we find it.

> **Mark Anderson** When you think about it, the Universe is about 13 billion years old, while Earth is around 4 billion years old. Life could have evolved and become extinct on billions of planets long before Earth was formed. By the same thinking, life could yet evolve on planets long after we are gone.

Steve Walker I think the news is very exciting, but I suspect that more research is being done to find out where the phosphine is coming from. I think that icy moons like Europa and Enceladus may be a potential place for life to exist.

John Mccann It's obviously proto-molecule ;-)

Ash Parker It's Darth Vader's home so be careful!

Donna Oliver Still waiting for the life on Mars issue to be solved.

SCOPE DOCTOR

Our equipment specialist cures your optical ailments and technical maladies

With **Steve Richards**

Email your queries to
scopedoctor@skyatnightmagazine.com

What eyepieces can I buy for my Celestron NexStar 8SE that will let me view the planets and the Moon with a reasonable field of view and eye relief, and would these work with Barlow lenses or be suitable for terrestrial viewing?

ED WATTERS

▲ Takahashi Abbe Orthoscopics are good for lunar and planetary observing

Your Celestron NexStar 8SE is a Schmidt-Cassegrain telescope (SCT) with a focal length of 2,032mm, making it an excellent instrument for Solar System observations. For both lunar and planetary observations, orthoscopic eyepieces in focal lengths of between 4mm and 9mm, like the Takahashi Abbe Orthoscopics, are a very popular choice, but they have narrow, 44° fields of view and very short eye relief. For a much wider, 82° field of view and a more reasonable eye relief of 12mm, the TeleVue 7mm or 9mm Nagler Type 6 would be an excellent choice. At a lower cost, a Pentax XW 5mm eyepiece would also be a good choice with its 70° field of view and 20mm eye relief.

Most eyepieces are suitable for terrestrial observing, but the image through an SCT is reversed left to right. So for terrestrial use, you should consider buying an Amici prism diagonal. A Barlow lens will work well, increasing magnification with the advantage of also increasing the eye relief.

Steve's top tip

Should I clean my dusty reflector?

This question gets asked a lot because the very nature of the Newtonian reflector design means that the mirrors are open to the atmosphere. Careful storage, with dust covers over the instrument's front end and eyepiece holder, can mitigate this potential problem. A thin coating of dust will have a negligible effect on your observing and the advice is normally to leave well alone, as the cleaning process can do more harm than good. However, if there is clearly organic matter like small dead insects stuck to the surface a careful clean is very much in order to stop chemical reactions etching into the mirror's surface.

Steve Richards is a keen astro imager and an astronomy equipment expert

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Dramatic scene

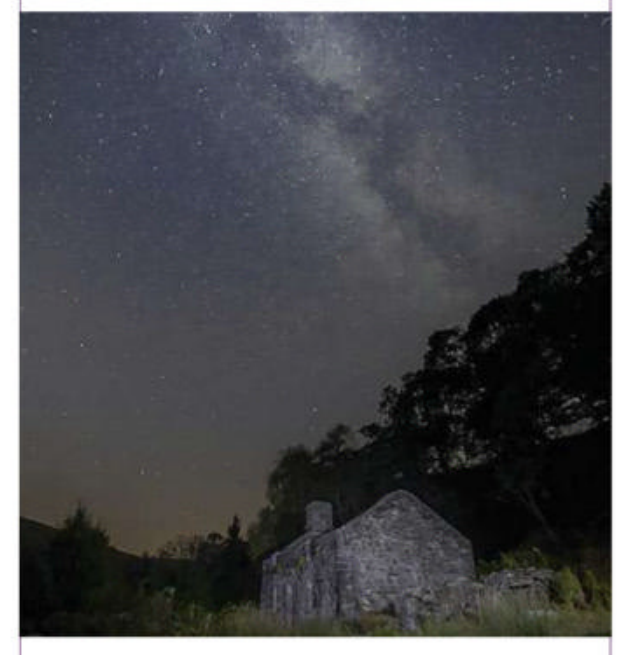
▸ I looked out of the window on 27 September and saw this! I think the clouds must be contrails, and the Moon, Jupiter and Saturn were also on view. I grabbed my Sony DSC-HX60 compact camera and got this photo from the bedroom window.
Roger Samworth, Nuneaton

Light concerns

May I compliment you and Dani Robertson on a very good article on light pollution ('Field of View', October issue). Could I be bold enough to ask her and her colleagues to approach my local council to try and teach them a few things. My back garden is overlooked by two or three offending streetlamps that plague my enjoyment of astronomy. It's a good job your magazine drops through the letterbox each month, as I've not seen a decent night sky yet!
Tony Noble, Rugby, Warwickshire

Instagram

lewissorcha • 24 September



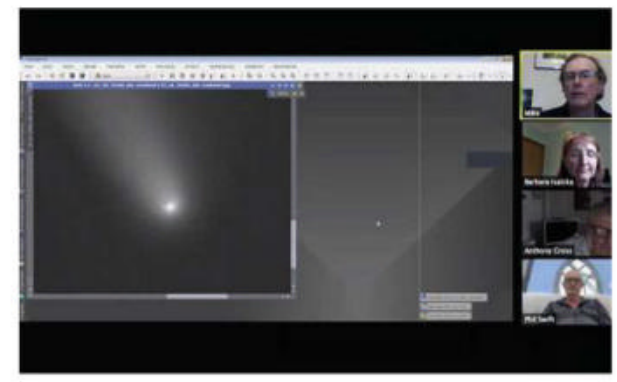
Miners cottage under the milky way... Transported back in time under the starry night sky, this ruin had a capability of coming alive once more. I could almost smell the turf fire and could hear the sound of a man coughing and calling in a dog for the night as the light spilled out from the doorway in which he stood. Can't beat the beauty of a clear starry sky...think we should all be prescribed one. #nighttimewildlifewonder #midwales #nighttimewalks #skyatnight

SOCIETY IN FOCUS

For the last quarter century **Manchester Astronomical Society** has met weekly at the Godlee Observatory, which we have been closely associated with since its opening in 1902 atop the Sackville Building at the University of Manchester. Since March the building has been closed due to lockdown, with all meetings cancelled.

Over the years, we've relied on having access to the observatory; the Godlee's telescopes, the 8-inch refractor and its counterbalancing 12-inch Newtonian built by Grubb of Dublin, were the last of only four so-called 'twin equatorials' designed to maximise the use of a small teaching observatory. The refractor could have been used to observe and photograph Comet NEOWISE, but it wasn't to be.

Fortunately, our Facebook page (now with over 1,600 members and friends worldwide) remains active and we are trialling Zoom for video meetings and talks each Thursday evening.



▲ Video links: Manchester Astronomical Society makes use of technology

Our monthly public lectures, dating back over a century, with a short gap during the Blitz of 1940-41, were similarly affected by lockdown. Our last guest speaker, in February, was *The Sky at Night* co-presenter Chris Lintott, who entertained us at our lecture venue, Manchester Metropolitan University. Plans have been underway to employ video conferencing for our autumn lecture season.
Kevin J Kilburn FRAS, Vice President, Manchester Astronomical Society
▸ www.manastro.org

COVID-19

This month we've selected only online events again

We pick the best astronomy events and resources available online this month

WHAT'S ONLINE

ONLINE TALKS

Royal Observatory shows

Hosted over Zoom by astro experts, 'Solar System Discovery' (above) takes an interactive, fact-filled tour of the Solar System, while 'Space Queries and Theories' are short talks after which you can ask space-related questions. Suitable for ages 7+.

www.rmg.co.uk/whats-on

Deep Astronomy

This long-running YouTube channel tackles tons of heavyweight astronomical subjects and features discussions with a range of expert guests.

www.youtube.com/user/tdarnell/featured

RADIO

Astro Radio

Featuring astronomy chat, science news and eclectic music throughout the week, Astro Radio is available via several music streaming services, such as **tunein.com**.

DOCUMENTARIES

A Year in Space

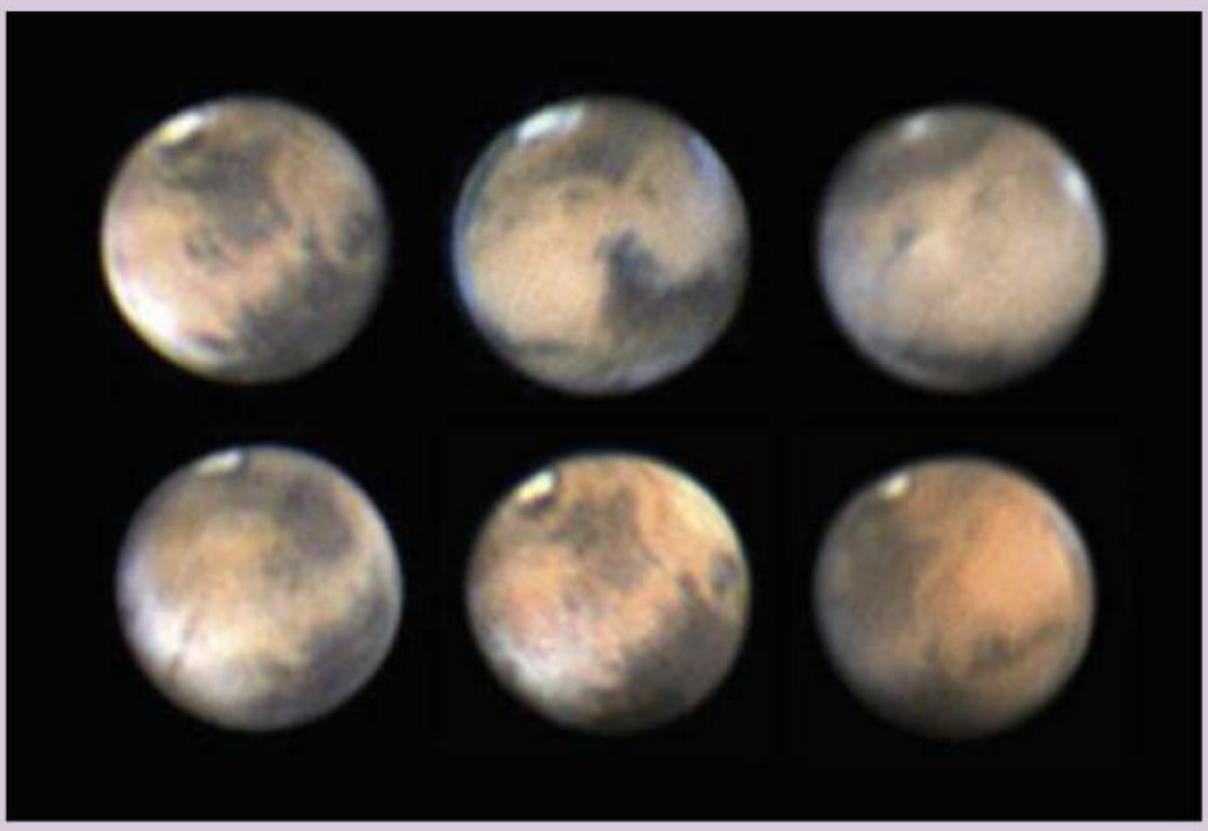
This 12-part documentary follows veteran astronaut Scott Kelly's year-long mission aboard the ISS with cosmonaut Mikhail Kornienko, testing the effects of living long-term in zero-g on the human body.

www.netflix.com

Horizon

Take a deep dive in the archives of *Horizon,* the BBC's long-running science programme, and discover episodes covering the height of the Space Race in the 1960s. **bbc.in/2FA67K1**

PICK OF THE MONTH



▲ Mars in focus: this year's National Astronomy Week celebrates the Red Planet

National Astronomy Week

14–22 November 2020

Although National Astronomy Week (NAW) 2020 has had to move online, it's still a great chance to focus on and celebrate the star of the show: Mars. Having just passed its best opposition for years, the Red Planet will be a high and bright feature of early evening skies from mid-November – perfect for some family observing time.

NAW organisers plan to live-stream views through amateur and professional telescopes, and provide live expert commentary. There will also be daily sessions aimed at young people organised by science outreach organisations, plus online talks by astronomical societies.

With interest in the planet already high thanks to the flurry of Mars missions launched this year, it's a great time to get young observers involved. Whatever equipment you have, get set up and tuned in – after all, Mars will not be as close again until 2033. Check out **astronomyweek.org.uk** for event details, Mars info, observing tips, Mars myths explained, and more.

Challenger: The Final Flight

This new Netflix documentary charts the tragic disaster that befell the Space Shuttle Challenger in January 1986, and how it changed spaceflight policy at NASA. The film features testimony from engineers, officials and the crewmembers' families.

www.netflix.com

CITIZEN SCIENCE

Help map the skies

Like history and know your constellations? Then why not join this citizen science project to spot and label more than 4,000 historical constellation maps and images in Chicago's Adler Planetarium collection?

bit.ly/maptheskies

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Stellina,
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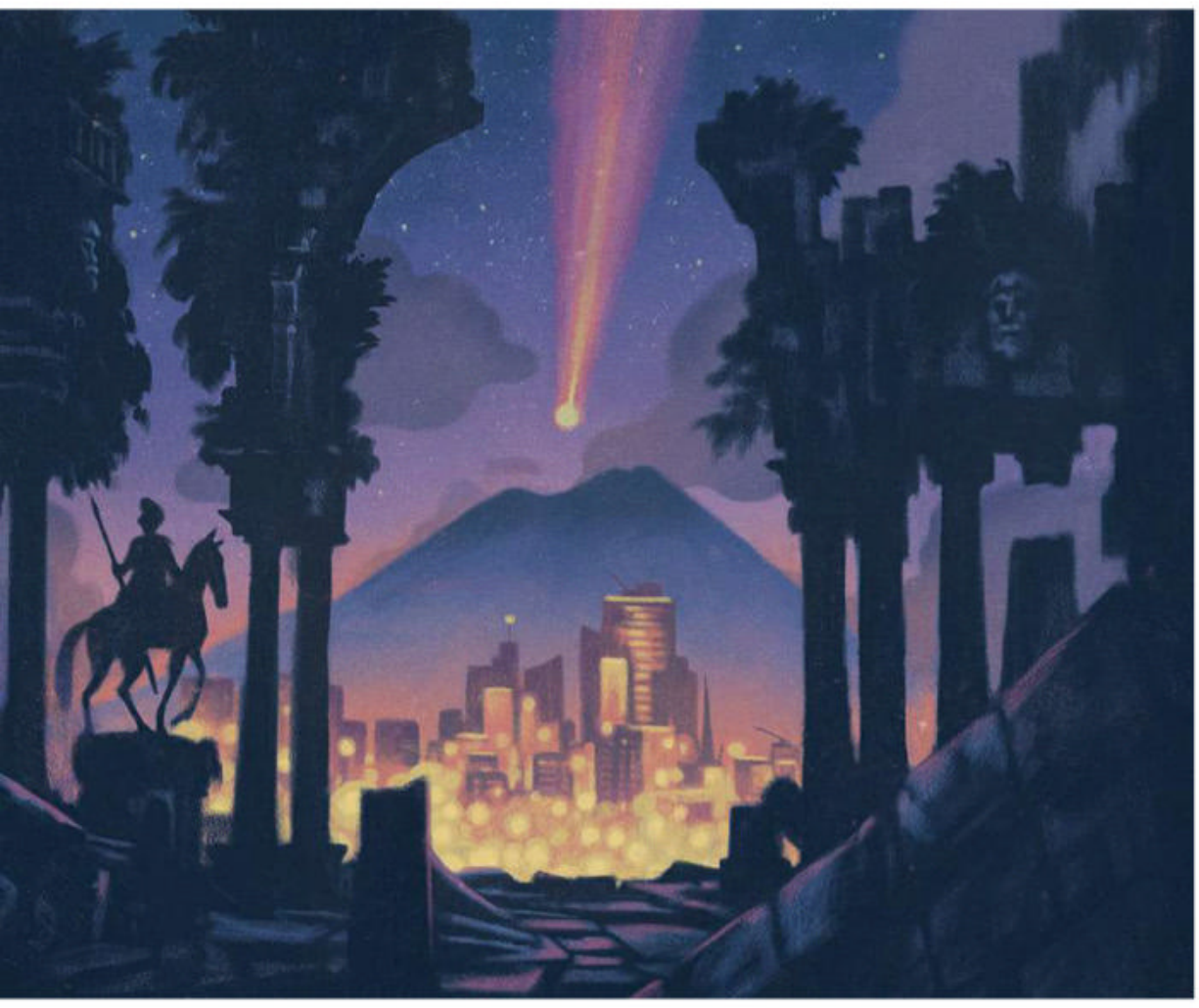
FIELD OF VIEW

A cosmic coincidence continues

Since ancient times, comets have been seen as a sign of impending disaster. During a global pandemic, did Comet NEOWISE keep up with the tradition?



A member of Birmingham Astronomy Society, **Paul Truelove** observes eclipses and occultations of Jupiter's moons with his hand-built reflectors, his interest sparked by Brooke Bond Tea's 1957 card series on astronomy

As long as there have been people to worry about what the future might hold, humanity has looked anxiously to the skies for signs and omens as some sort of indication about what might lie ahead.

Given the confidence and complacency which our scientific knowledge has bestowed, it is hard for us today to appreciate the very real fear and serious consideration that was accorded to the most transient of unusual natural phenomena. Even relatively rare meteorological happenings, such as a lunar halo appearing with the chance placement of a planet in it, gave rise to such sayings as, "If the moon is surrounded by a halo, and a planet stands in it: robbers will rage," which everyone then believed.

The sudden unexpected appearance of an object as dramatic and mysterious as a bright comet was therefore deeply unsettling. No wonder that comets have always been taken to be harbingers of catastrophic or pivotal events. It is a seriously weird fact, however, that all through recorded history bright comets have often managed to appear just at the very moments that dramatic and world-changing circumstances were underway.

Perhaps the best-known example is Halley's Comet, which flashed across the skies in 1066 before King Harold's defeat at the Battle of Hastings. The Bayeux Tapestry records this apparition and also shows a number of nobles from King Harold's court all looking up and pointing anxiously at the 'hairy star' which had so silently appeared.

It is widely known that Julius Caesar was murdered in 44 BC, but what is not so well known is that – when his adopted son, Octavian, organised games and a funerary service to deify and celebrate his father, four months after his death – with incredibly appropriate timing, the bright comet of 44 BC (C/–43 K1) shone in the skies at the same time. We have many examples of Roman Denarii silver coins from this era and there is an example with the impression of a 'star', which has been claimed to be a representation of Caesar's Comet.

On 2 October 1264, Pope Urban IV died and, amazingly, this important event was also marked by the appearance of yet another bright comet. We know it today as the Great Comet of 1264 (C/1264 N1); it is said that the Pope fell ill on the day it appeared and died on the day it disappeared.

Closer to our own times, Mark Twain was born in 1835 as Halley's Comet rounded the Sun; he died from a heart attack in 1910 just as it returned. There are numerous other examples.

How strange and improbable it is then, that now, after such a long absence of bright comets from our skies, Comet NEOWISE should seemingly choose to continue this same centuries-old tradition and be at its spectacular best during the very months that COVID-19 took hold as a pandemic and swept around the planet. What are the chances? Perhaps, like the ancients, we should have taken its arrival to be an omen of things to come.

SEAN LEWIS

BBC

Sky at Night MAGAZINE

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BBC Sky at Night MAGAZINE

Sega Toys Homestar Flux

Satin Black

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Brilliant glass lenses and our brightest LED to date make everything look vibrant and sharp.
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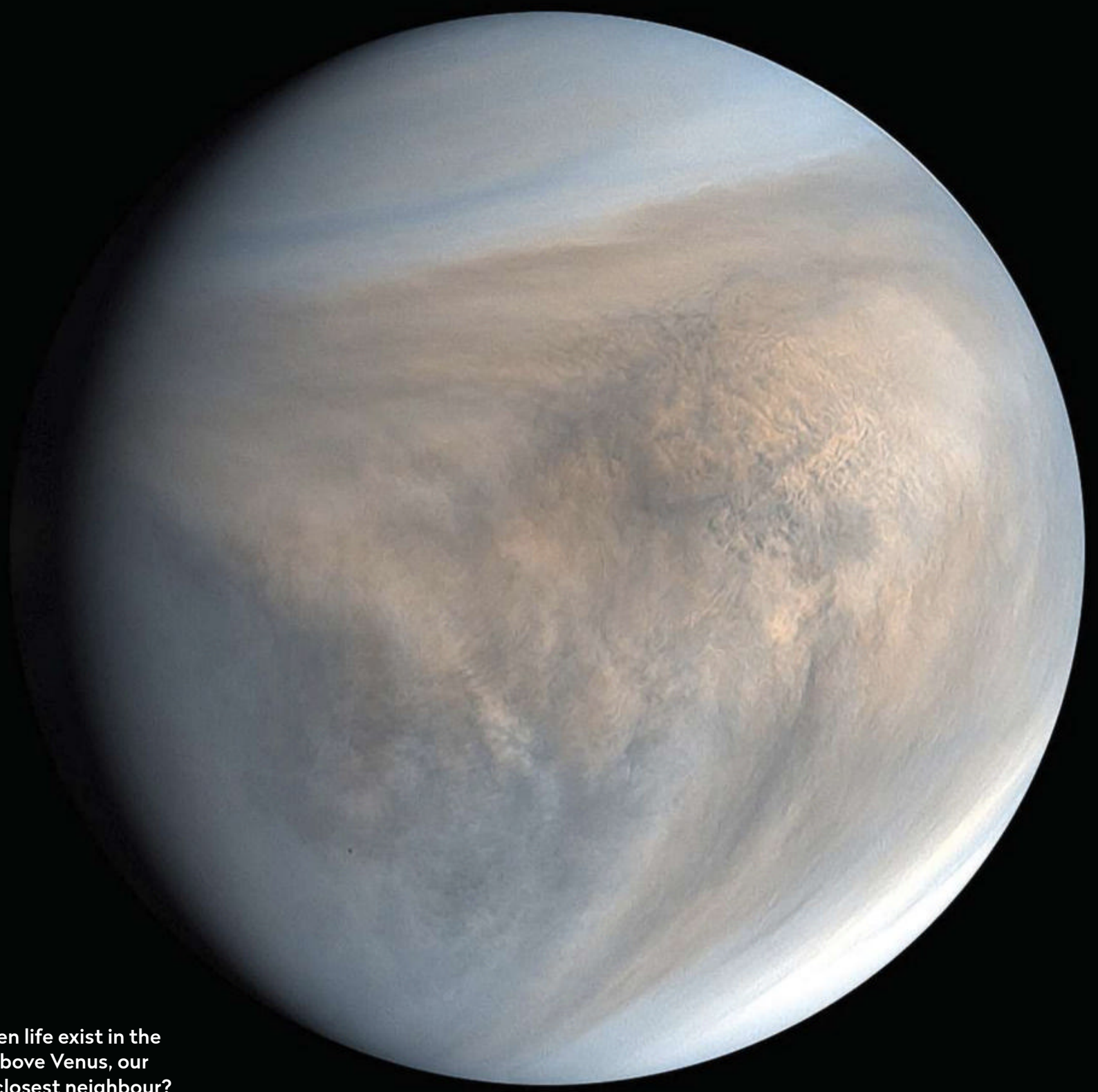
SEGA TOYS flx

www.segatoys.space 174GBP

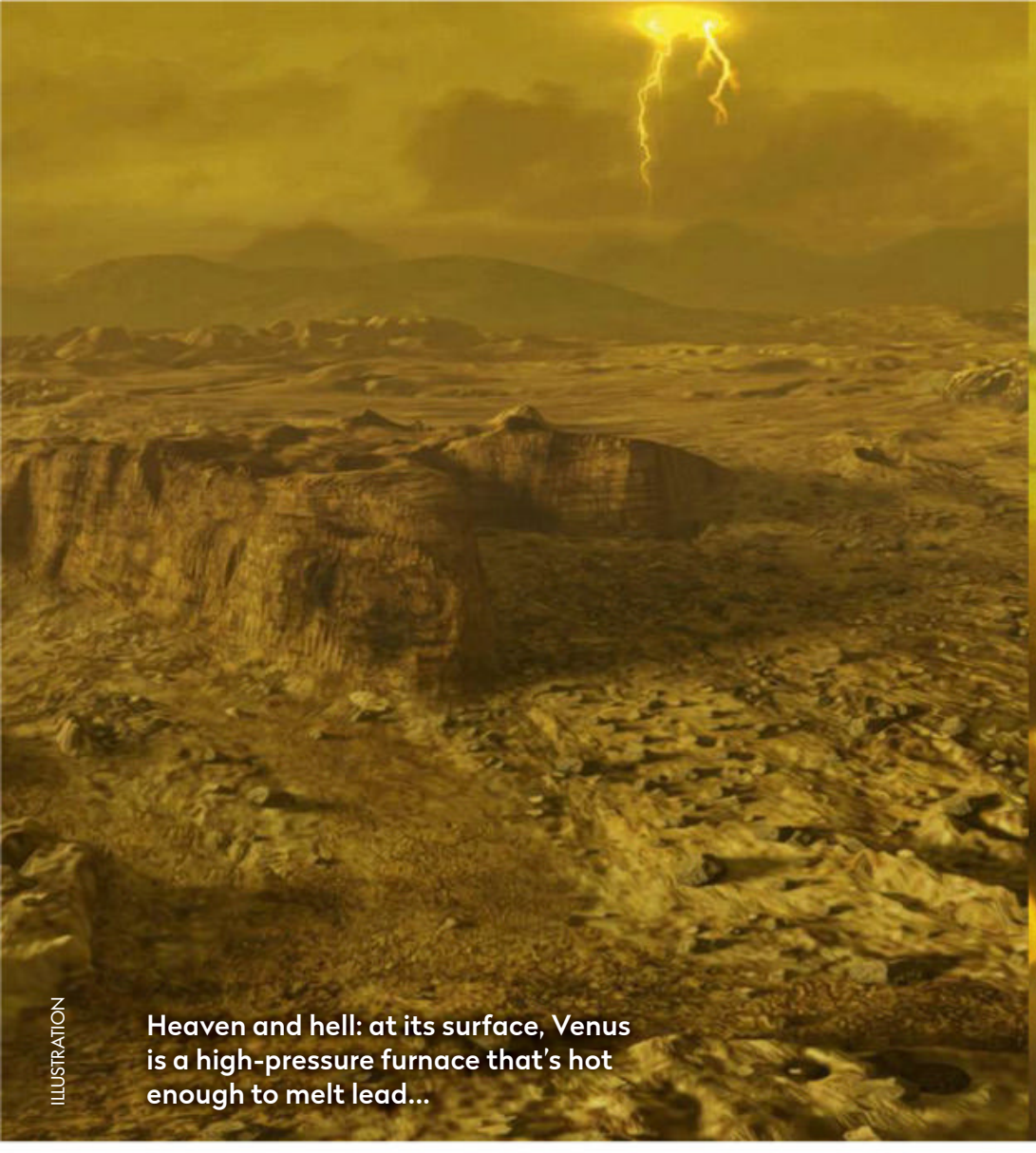
Microbial life on VENUS

What are the chances?

The detection of phosphine in Venus's atmosphere has raised the possibility that it could be produced by lifeforms on the hellish world. **Mark A Garlick** considers the evidence



Does alien life exist in the clouds above Venus, our second closest neighbour?



Heaven and hell: at its surface, Venus is a high-pressure furnace that's hot enough to melt lead...

ILLUSTRATION

...but venture up above the cloud deck and conditions are far more friendly

ILLUSTRATION

Arguably, it is the most inhospitable terrestrial body in the Solar System. The surface temperature, around 460°C, is enough to melt tin, zinc and lead. The atmospheric ground pressure is 93 bar – like that beneath 900m of water on Earth, while the atmosphere is choked full of carbon dioxide and clouds that drip sulphuric acid. The sky behaves more like a fluid than a gas, so dense that the winds can easily move small rocks. Welcome to hell – otherwise known as Venus.

Yet despite this most extreme environment, scientists have long speculated about life on Venus, now or in the past – among them Carl Sagan and biophysicist Harold Morowitz; and in September this year, the debate was reawakened with the detection of phosphine there – on Earth, a known indicator of biological agencies.

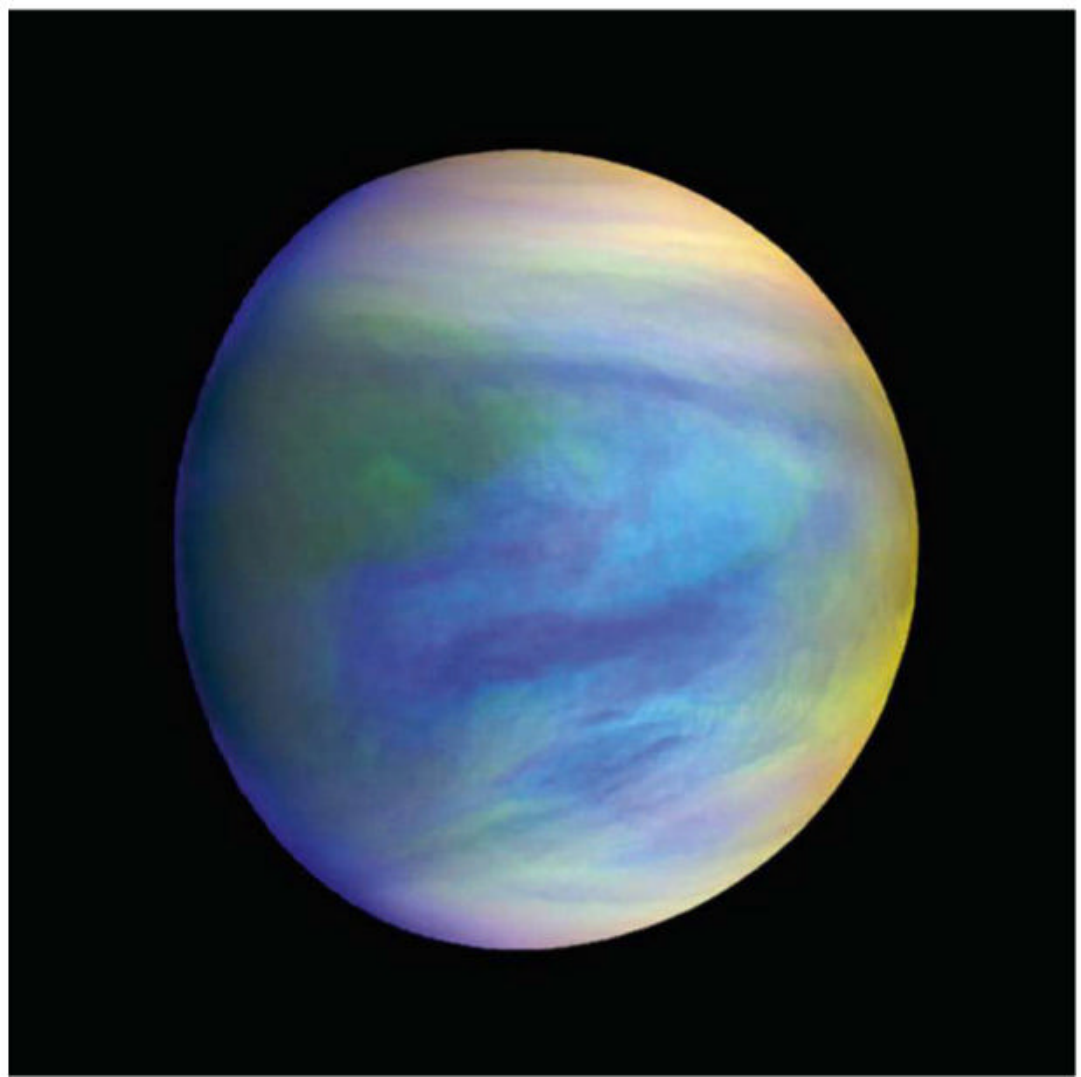
Certainly, billions of years ago, Venus, Earth and Mars were much more alike than they are now; they formed at a similar distance from the Sun and from the same rocks and metals. If life took root here, it might well have done so on our sister worlds, and could have persisted until global climate catastrophes and other factors turned Mars into a freezing desert and Venus into an inferno.

Cloudy, with a chance of life

The existence of life on Mars now, though, is contested (see boxout, page 32), and on Venus – given its environment – seems at first exceedingly unlikely. But there is a caveat: Venus is only a heat trap on its surface. At an altitude of 50km, the atmospheric pressure drops to 1 bar and the temperature is comparable to a temperate day on Earth. This is Venus's own habitable zone and it raises the question: could life flourish among its clouds?

Venus is an extremely cloudy world. Only 20 per cent of incident sunlight percolates down to the surface. Yet the atmosphere is not quite featureless; contrast-adjusted photos reveal the presence of dark patches or bands, which are particularly visible at ultraviolet wavelengths. These so-called 'unknown absorbers', discovered more than a century ago, are caused by mysterious substances that block most ultraviolet light and a portion of visible light, rendering these regions comparatively dark. In August 2019, a team of researchers led by Yeon Joo Lee at the Technical University of Berlin published a report in *The Astronomical Journal*, examining how these absorptions affect Venus's climate.

"The particles that make up the dark splotches have been suggested to be ferric chloride, allotropes of sulphur, disulphur dioxide and so on, but none of these, so far, are able to satisfactorily explain their formation and absorption properties," explained Lee.

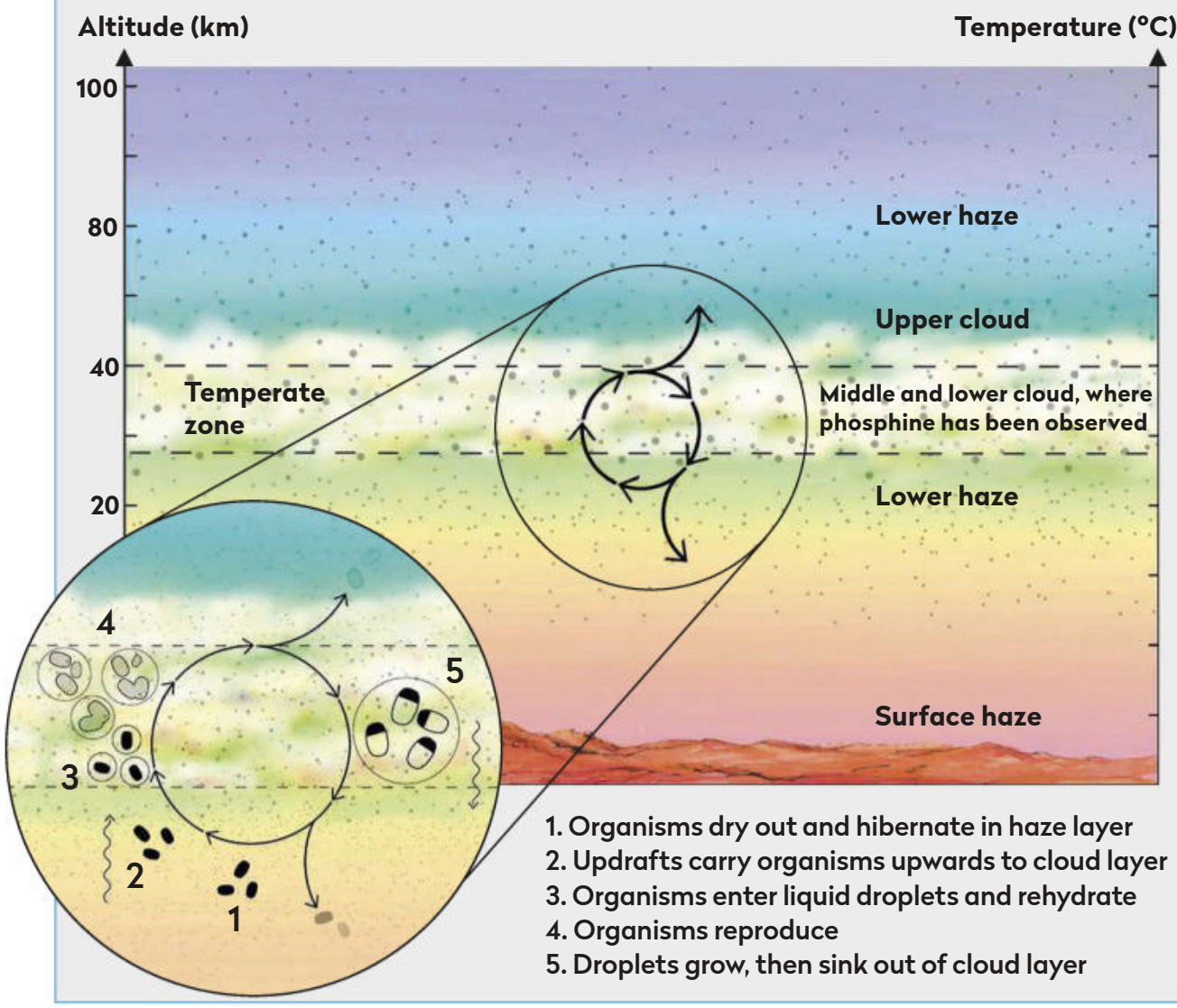


▼ Dark mysteries: a composite ultraviolet and infrared image of Venus from Japan's Akatsuki probe. Scientists including Carl Sagan have long speculated about the nature of the dark patches shown

MARK GARLICK X 2, INSTITUTE OF SPACE AND ASTRONAUTICAL SCIENCE/JAPAN AEROSPACE EXPLORATION AGENCY, ESO/M. KORNMESSER/L. CALÇADA & NASA/JPL/CALTECH, LIFE CYCLE ILLUSTRATRION: © SARA SEAGER ET AL/2020/ WWW.LIEBERTPUB.COM

Lifecycle in the clouds on Venus

Astrobiologists have suggested a way that life could exist in the clouds above Venus in a cycle between atmospheric layers



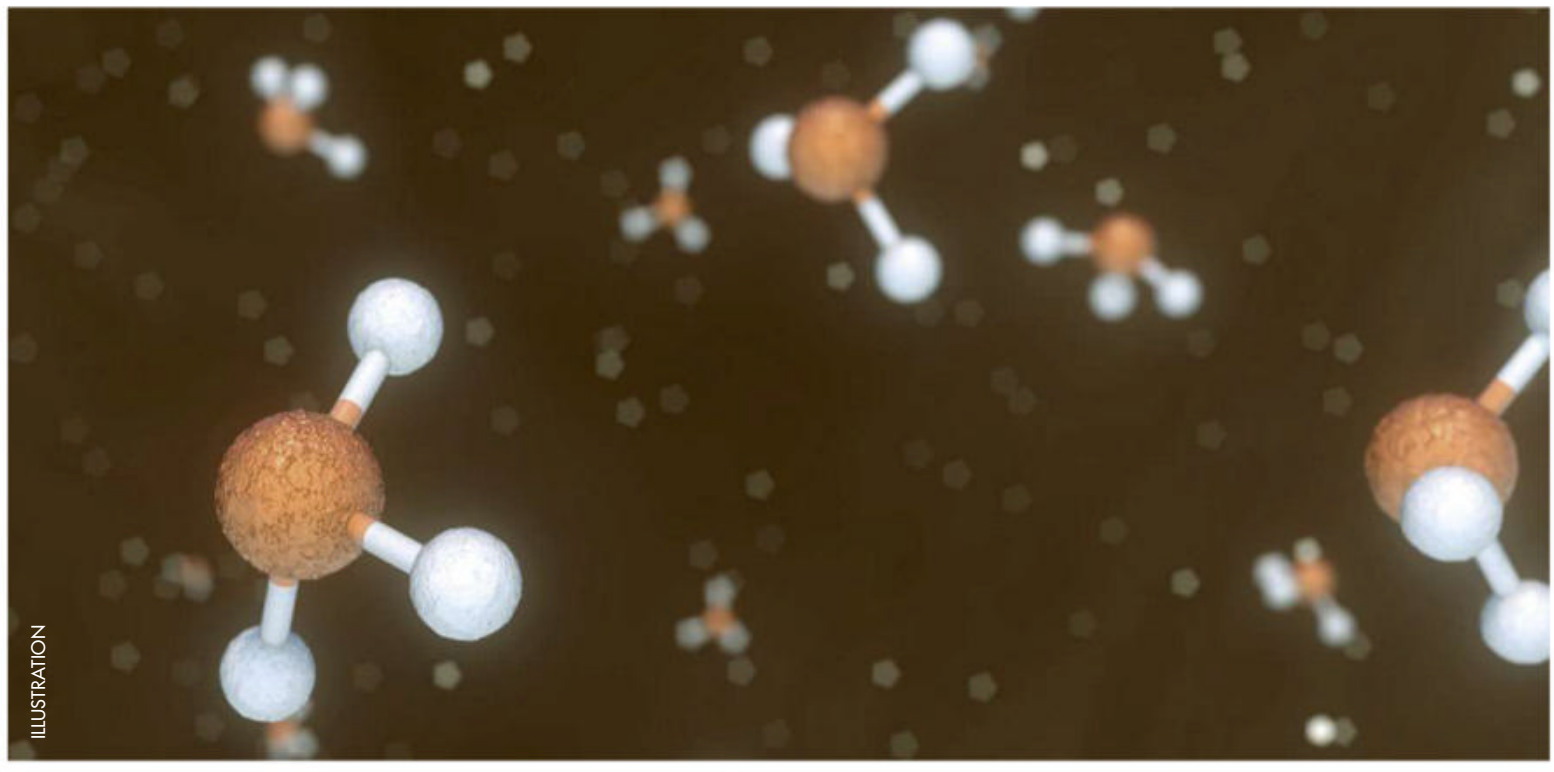
What we do know, at least, is that these unknown materials are comparable in size to light-absorbing bacteria back on Earth, and exhibit a similar absorption profile. This is what led Sagan and Morowitz, in the 1960s, to speculate that these dark patches might be due to the presence of microbes floating in the clouds. Other authors have taken a similar stance, notably David Grinspoon of the Planetary Science Institute in Arizona, who dedicated a chapter to the subject in his 1998 book *Venus Revealed*.

New momentum

In September this year, the debate gathered new momentum with the discovery of the spectral signature of phosphine in Venus's atmosphere. Phosphine (PH_3) is a molecule consisting of a single phosphorous atom bonded to three hydrogen atoms. Phosphine is also present on the gas giants, which are rich in the hydrogen needed to make it, and on Earth. On our home world, however, with negligible free hydrogen in the atmosphere, virtually all of the phosphine is produced entirely by biological activities.

Like methane, its detection is a possible indicator of life, and some astronomers have proposed looking for it in the spectra of exoplanets' atmospheres as they transit their parent stars. It isn't absolutely certain that the phosphine on Venus is biologically created, but scientists have yet to identify other chemical processes that can make it there. And this is why its potential existence is so exciting. Phosphine, and the unknown substance absorbing ultraviolet light, taken together make a good case for studying the subject more closely.

On Earth, microbial life is everywhere. It thrives around sea-floor volcanic vents, in hot springs, in deserts, in ice and in the sky. Surface bacteria can ►



► Sign of life: the phosphine molecule is made up of one phosphorus atom and three hydrodgen atoms

▸ be swept into the atmosphere, find their way into droplets of water, and survive at altitudes as high as 4km. Life is, it would seem, undoubtedly very hardy. The humble tardigrade (or water bear) can even survive after exposure to the vacuum of space, seemingly unaffected by cosmic radiation and microgravity or, indeed, the lack of air. We know that some bacteria bask in acidic conditions, feeding off carbon dioxide to produce sulphuric acid – both of which are in abundance in the atmosphere of Venus.

So serious are astronomers about this that Sara Seager, an astrophysicist at the Massachusetts Institute of Technology (MIT), has even come up with a possible life cycle for the planet's cloud-based lifeforms. The microbes, she says, might thrive in droplets of sulphuric acid within the Venusian habitable zone, at around an altitude of 50km.

As the droplets grow, in the same way that air-born water droplets on Earth do, they would start to rain from the lower cloud decks, straight into the much hotter haze layer directly beneath, which would evaporate them. Without the surrounding droplets to protect the microbes they carried, the latter would go into a dormant state – Seager calls them 'spores' – in order to survive the extreme conditions.

Above the clouds: should our search for life on other worlds include the Venusian atmosphere?

ILLUSTRATION

Eventually these spores would be kicked back up into the temperate zone by winds to be rehydrated, ending their suspended animation and restarting the cycle.

Looking for life

Several other places in the Solar System are often touted as potential abodes of life, as yet undiscovered (see boxout, below). But among these worlds, it's Venus that is the easiest to reach. At an altitude of 50km, floating habitats would be the ideal launch pad from which to search for signs of life in the clouds. Perhaps our search for extraterrestrial cousins among the planets should begin there.

Dr Mark A Garlick is a former professional astronomer, now a freelance writer, illustrator and animator specialising in space

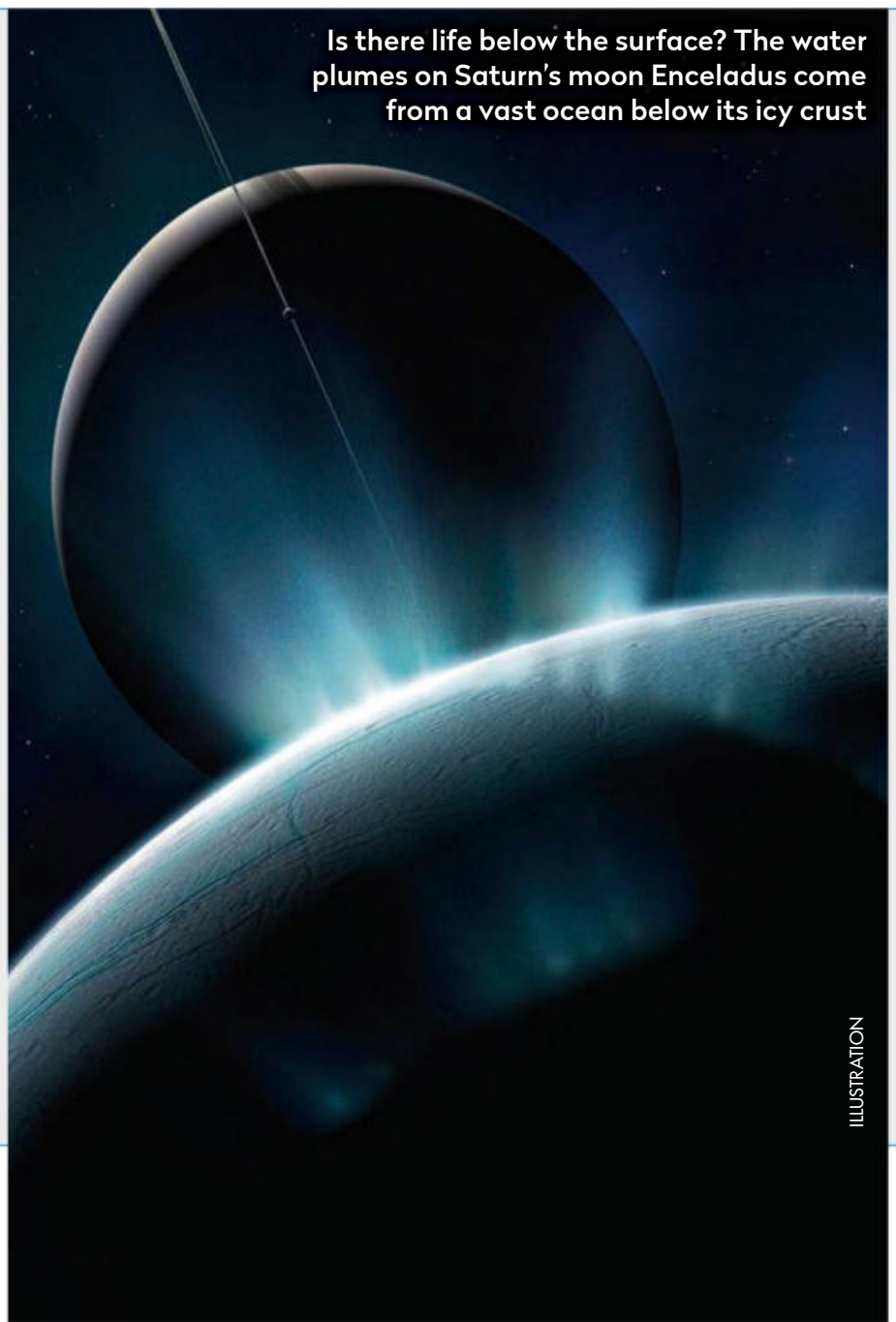
A habitable abode

Elsewhere in the Solar System there are several environments that might support life

Mars, of course, has long been a favourite among astronomers for life elsewhere around the Sun. In 1976, the Viking missions scratched the Martian soil and tested for products that had been created through biological metabolism. For a while, things looked promising, but the Vikings' other experiments detected no supporting evidence – no signs of the organic molecules needed to sustain life. Mars came under the spotlight again in 1996 with the discovery of what looked like fossilised bacteria in a meteorite known to have come from Mars. In the interim, most scientists have concluded that both reports remain inconclusive at best.

More recently, speculation has turned to the ice moons of the gas giants – especially Enceladus, Titan and Europa. Titan, Saturn's largest moon, is extremely cold but it has a thick nitrogen atmosphere and, some say, conditions there mirror what they were on Earth when life first took hold. Enceladus, also in Saturn's system, and Europa, orbiting Jupiter, are both known to have icy crusts floating on relatively warm, briny seas.

Could these be teeming with life? The only way to know is to sample these primitive seas – perhaps a submarine on Europa, or a flight through the plumes of Enceladus to sample the water jets spewed from beneath the ice and analyse the material.



Is there life below the surface? The water plumes on Saturn's moon Enceladus come from a vast ocean below its icy crust

ILLUSTRATION

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Thank you, Sylvia

Sylvia left a gift in her Will to help conquer Stroke

The first we knew of Sylvia was when we received notification of the gift she'd left us in her Will. Shortly after, a beautiful story of a much-loved woman began to unfurl.

Friends remembered Sylvia's kind-heart and her wish to help others. She spent part of her adult-life caring for her mother, and developed a passion for medicine. Becoming a medical secretary was her next step and, in the course of her career, she discovered the devastating impact a stroke could have on people and their families. She saw that research and treatment were vastly under-funded, and she decided to remember the Stroke Association in her Will.

Sylvia's gift has helped fund our work to conquer stroke. She's supported research to prevent and treat stroke, and she's helped care for survivors. And that's something you can do too – in the same way.

If you would like to learn more about remembering the Stroke Association in your Will, please get in touch.

Call 020 75661505 email legacy@stroke.org.uk or visit stroke.org.uk/legacy

Stroke association

Celestial treasure: views of the Double Cluster in Perseus can be enjoyed with the naked eye, binoculars or a telescope

GALACTIC GATHERINGS

Will Gater explores the science and splendour of some of the most striking star clusters in November's night sky

When it comes to star clusters, there are few months that offer such a wide range of targets as November. At the start of the month, the cluster-rich regions of the summer sky are low in the southwest as darkness falls, while a quick scan with binoculars can take you on a mesmerising journey through droves of sparkling stellar groups scattered among Cygnus, Cassiopeia and Perseus. Here we've gathered together eight clusters that we think really highlight the spectacular selection that's on offer, and as we go we'll also look at the astrophysics that underpins their existence. With the Moon out of the way from around 6 November, you can start seeking them out straight away! ▸

HANNES BACHLEITNER/CCDGUIDE.COM

M26 lies in a star-rich region of the constellation Scutum

Messier 26

Look to the southwest at the end of astronomical twilight (around 18:30 UT), and if your skies are dark and transparent you may be able to make out a bright patch hovering over the horizon; this is the Scutum Star Cloud, a particularly star-rich swathe of the Milky Way in the constellation of Scutum. There are several beautiful star clusters in and around the Scutum Star Cloud, but the one we're looking for is M26. Binoculars should reveal it against the sparkling background stars, but a medium to large aperture telescope is preferable; using the latter you can find it by 'star-hopping' just under three degrees east (and a little south) from the third magnitude star Alpha (α) Scuti, via the fainter star Delta (δ) Scuti.

▲ Stop off at M11, the Wild Duck Cluster, on the way from M26 to NGC 6704 at the top of Scutum

The birth of an open star cluster

Stars aren't typically born in isolation, but together in huge stellar nurseries

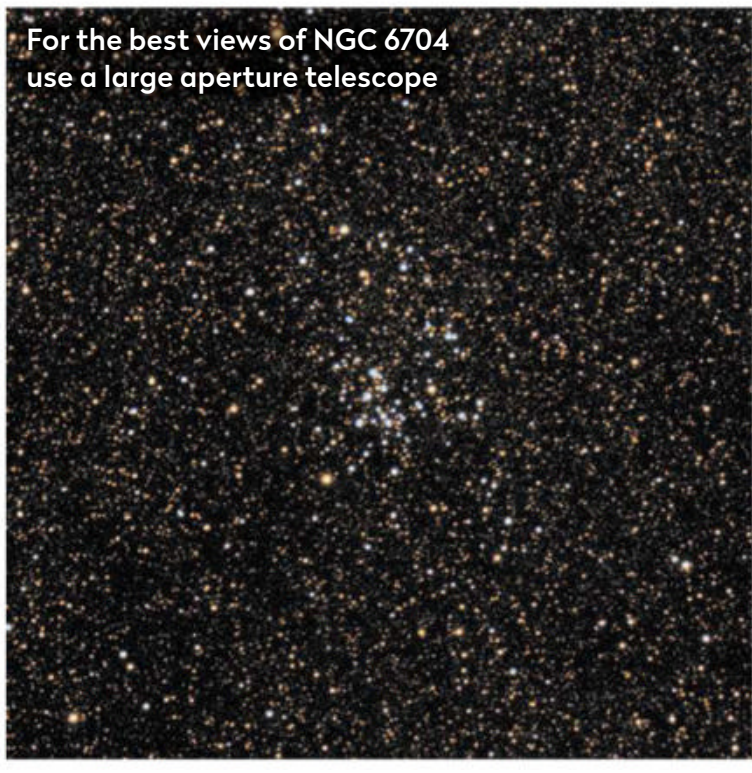
At this point in our tour we're exploring a region that sits roughly in the direction of the Milky Way's centre. You don't have to look far in this part of the night sky to see signs of the early stages in a star cluster's life.

The most obvious are the immense, dark nebulae that weave across this region. It's within cold, dusty clouds like these that clumps of gas can form; if these grow sufficiently massive, nuclear reactions can fire up in their hearts and they'll start to shine as newborn stars.

A good example of this process lies just below the stars of Scutum in the Eagle Nebula, M16. This is one of the most striking star forming regions in the sky, though it's best viewed in summer. Amid the swirling clouds of this nebula, many stars have formed close together and a young open cluster is emerging.

NGC 6704

We're not going far for our next object. In fact NGC 6704 is just over four degrees away, towards the 'top' of Scutum. To get there we'll cross the brightest patch of the magnificent Scutum Star Cloud; if you're using a Go-To telescope it'll take mere seconds for the mount to slew to the cluster, but if you're doing things manually this is a great opportunity to take a leisurely wander through the rich star fields and, perhaps, stop by the Wild Duck Cluster, M11. NGC 6704 is another cluster that is best seen in a large aperture telescope. To find it, place the fourth magnitude star Beta (β) Scuti in your finderscope and then move about one degree east and half a degree south. The cluster should then be in the eyepiece or at least close by. ▸



For the best views of NGC 6704 use a large aperture telescope

CHART BY PETE LAWRENCE, WILL GATER X 3, MICHAEL BREITE/ STEFAN HEUTZ/ WOLFGANG RIES/CCDGUIDE.COM, RICK JOHNSON/MANTRAPSKIES.COM

The open cluster M39 in the constellation of Cygnus is a wonderful imaging target

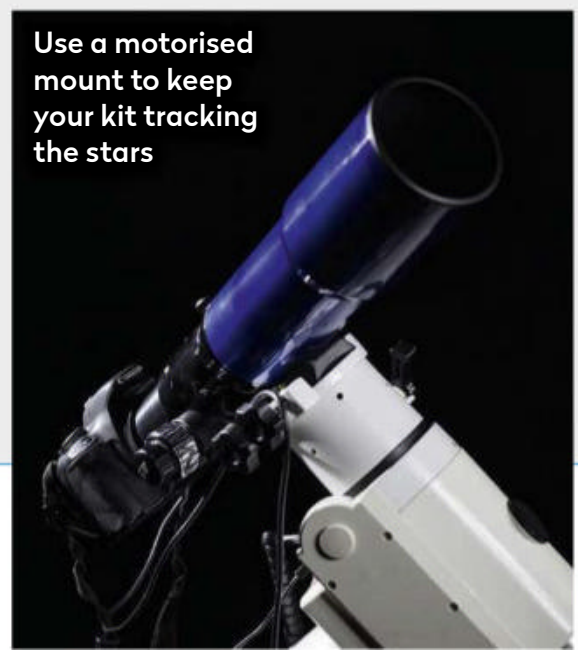
Imaging highlight: Capture the star cluster M39

The clusters of autumn are great for astrophotographers who are just starting to capture the night sky and looking for a challenge

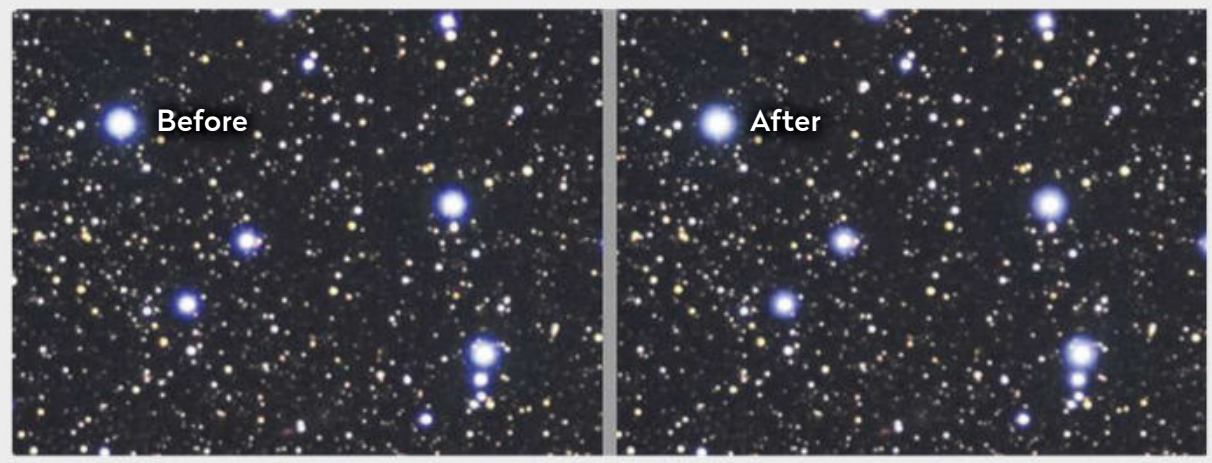
Star clusters make great training targets if you're new to deep-sky imaging, and November certainly isn't short of bright ones to choose from. Messier 39 in Cygnus is a perfect example. It's home to a decent number of reasonably bright stars, sits high above the horizon in the early evening this month and is large enough on the sky that it looks impressive in images captured with introductory level deep-sky imaging equipment.

Equipment

The cluster spans about 40-arcminutes, and it will look nicely placed against the background stars in the field of view of a DSLR attached to scopes with focal lengths as short as around 400mm. Then you just need a motorised mount to track the sky during long exposures. It's worth investing in a Bahtinov mask for the task of getting things in focus, which you'll need to tackle once you've got the cluster stars in your camera's sights.



Use a motorised mount to keep your kit tracking the stars



▲ Natural look: bluish star haloes can be toned down with an image-processing program

Taking your frames

When you're shooting the frames to make your final picture, take at least 15-20 minutes' worth of exposures. Depending on your local light pollution levels, this could mean individual sub-exposures (or subs) of as little as a few tens of seconds in length up to a minute or so, or more.

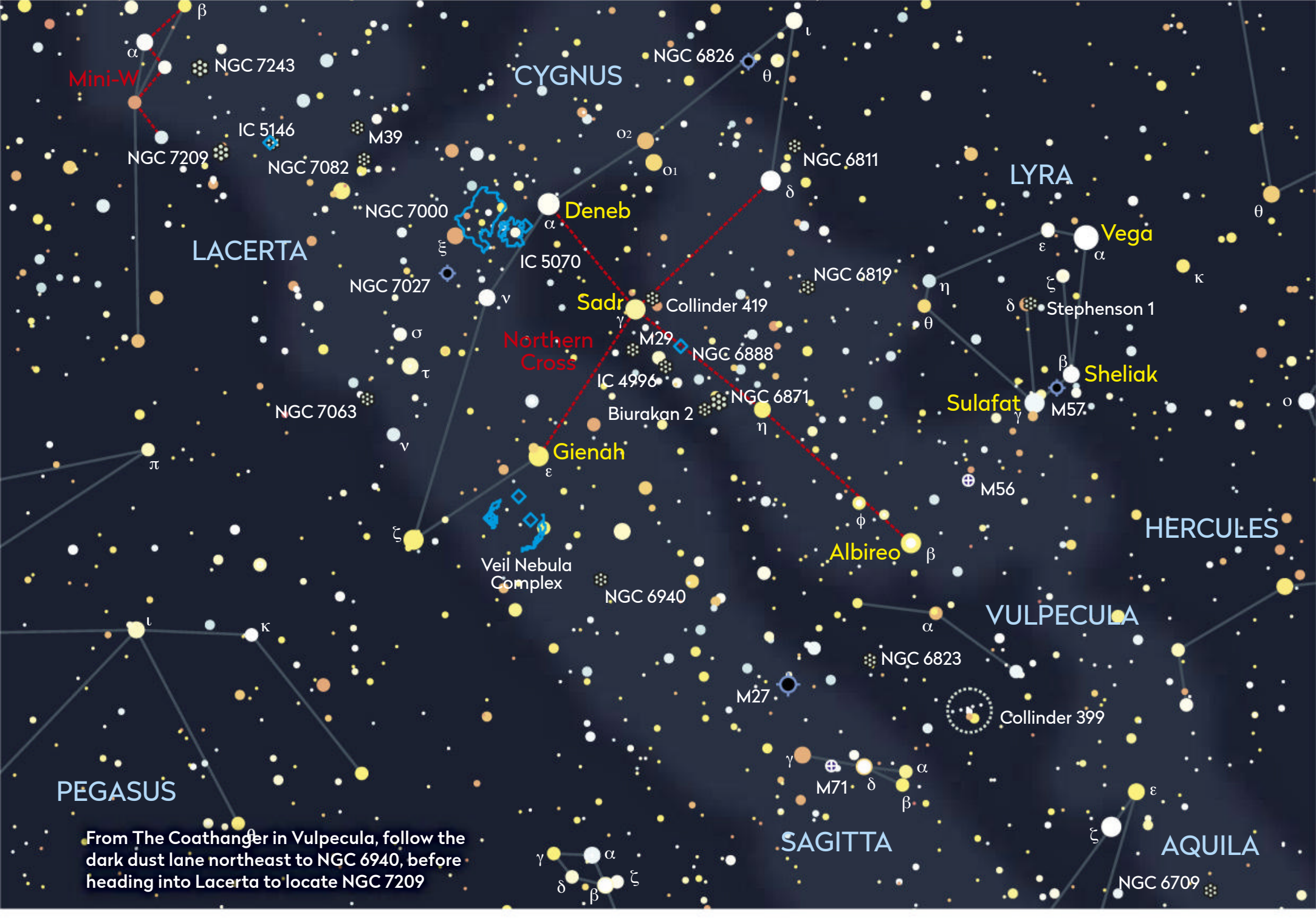
Stacking your frames

When sorting your subs, discard any that show tracking imperfections or the effects of wind gusts, where the stars appear slightly blurred or misshapen. Then process the images in stacking software. The free DeepSkyStacker is still the go-to program for beginners.

Tweaks and adjustments

When making the usual contrast, colour balance and 'curves' tweaks to your final image, you may notice that brighter stars have purple, cyan or blue haloes around them. These can appear for a variety of reasons, but a way to get rid of them is to use the 'Replace Colour' tool in an image-processing program like Photoshop or GIMP.

Set the tool's 'fuzziness' to near its maximum, then click on a point about halfway into the halo's radius. Lower the 'Saturation' slider within the tool and the tint of the haloes should disappear, making the picture look more natural.



The Coathanger

From Scutum we're now going to traverse the stars of Aquila and Sagitta to focus on a wonderful sight in the realm of Vulpecula, the Fox. The Coathanger – also known as Collinder 399 or Brocchi's Cluster – sits about four and half degrees to the south of the star Anser (Alpha (α) Vulpeculae).

It's a great target for a pair of binoculars, as the cluster appears about one and a half degrees across on the sky and contains mostly fifth and sixth magnitude stars.

There are several ways you can go about tracking it down, but probably the easiest is to slowly scan the region between the bright stars Albireo (Beta (β) Cygni) in Cygnus, and Altair (Alpha (α) Aquilae) in Aquila. From a dark-sky location it is a fine sight, situated among the granular star fields and dark galactic dust lanes.


You'll get a good view of NGC 6940 through a larger telescope

NGC 6940

The Coathanger sits within a prominent dust lane – known as the Great Rift – that runs all the way from the Galactic Core region through the constellation of Cygnus and beyond. To find our next cluster we need to follow this celestial silhouette to the northeast, in the direction of the third magnitude star Zeta (ζ) Cygni. While this dark path to NGC 6940 is easily visible to the naked eye under dark skies, you'll need a larger scope to see the cluster well. If you're using a manual mount, find the target by first selecting a low power eyepiece – around 30x magnification is ideal. Next, place the fourth magnitude star 41 Cygni on, or near to, the westernmost

CHART BY PETE LAWRENCE, BERNHARD HUBL/CCDGUIDE.COM X 2, HANNES BACHLEITNER/CCDGUIDE.COM,

The Coathanger makes an ideal target for a pair of binoculars

edge of the field of view. Then move south by about two degrees to see NGC 6940.

NGC 7209

Our next object takes us northeast from Cygnus over into Lacerta, and as we're moving further east in the sky, the objects we look at now will be well-placed for more of the night than some of our earlier targets.

Our current target, NGC 7209, will sit nice and high right up until the small hours during the first half of November, after which the Moon starts to interfere. NGC 7209 lies close to the diamond-shape of stars that make the head of Lacerta.

To find it in a medium aperture scope, place the mag. +4 star 5 Lacertae on the northern edge of the field of view through a low-power eyepiece (ideally around 20x magnification). Then move the scope a little over four degrees to the west and you should be able to pick out the cluster's stars. ▸

NGC 7209 is particularly well-placed for observing during the first half of November

Scattered among a spiral

The cloudy band of the Milky Way is home to many wonderful star clusters

You may have noticed that as we've been moving to objects a little higher in the sky, we've been weaving in and out of the bright band of the Milky Way. In fact, most of the clusters in this guide appear close to it on the sky.

Why might this be? The answer is that when we're looking into the misty light of the Milky Way we're gazing into the disc of our Galaxy. This disc is composed of structures known as spiral arms and it's in these glittering streams of stars that we find the star factories of the Milky Way.

As we've already seen, it's in these star-forming nebulae that open star clusters begin their lives, so it follows that many of the young star clusters we see today sit close to the spiral arms that make up the band of the Milky Way.

NGC 1245 can be located in Perseus near Mirfak, below the Double Cluster

Wanderers within the Galaxy

Clusters don't stay together forever, and soon the family drifts apart

As an open star cluster grows older it's thought that gravitational interactions cause the stars in the grouping to drift apart, scattering throughout space.

This likely happened with the Sun long ago. Indeed, astronomers today are studying the chemical composition of nearby stars to pinpoint potential members of our star's maternal cluster.

Understanding the motions of the stars, and star clusters, in the night sky can shed light on their history. One mission that is proving to be a powerful tool in this respect is the European Gaia satellite.

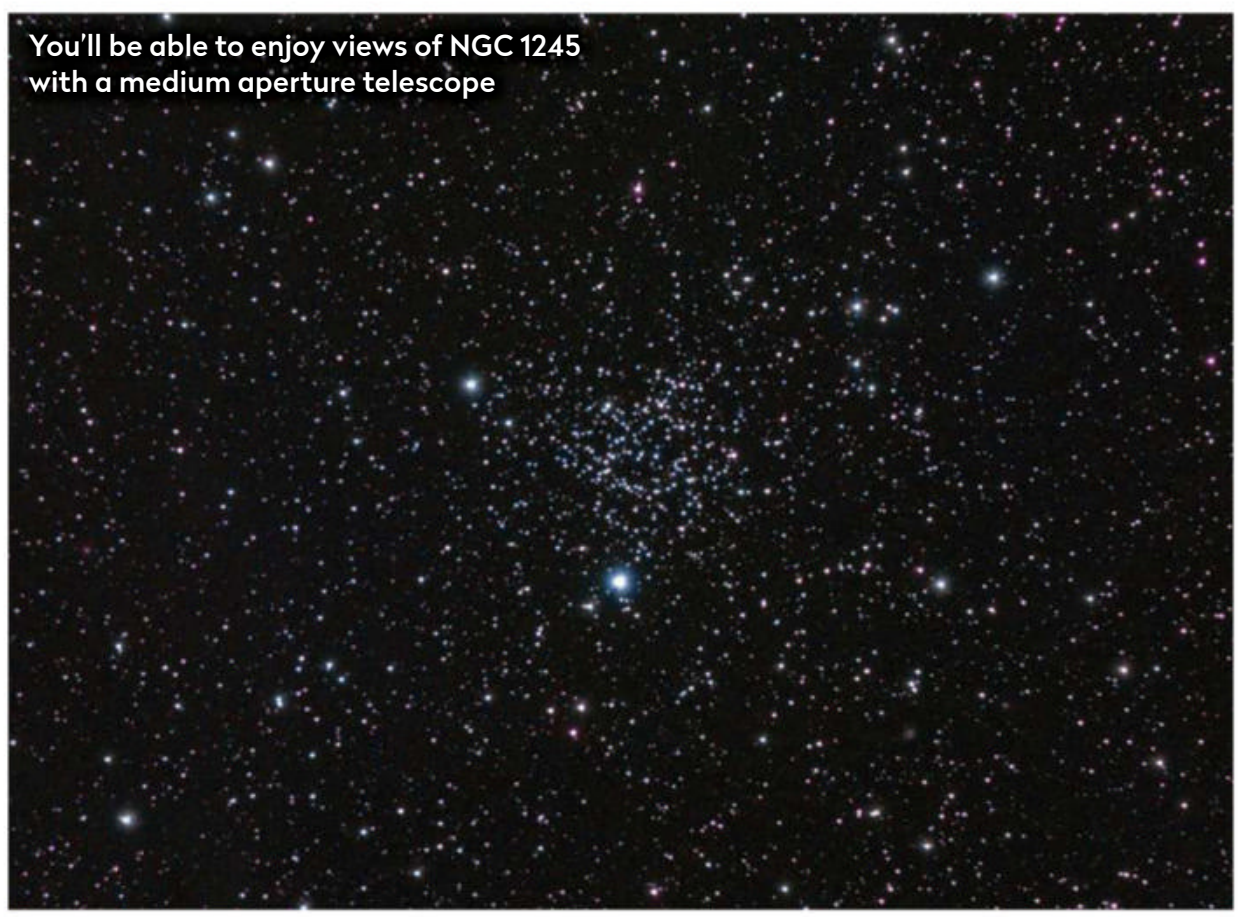
From orbit it has been charting the positions and velocities of millions of stars in our Galaxy, giving researchers a view of how the stellar inhabitants of the Milky Way are moving on astronomical timescales, and the relationships between them.

NGC 1245

▸ We're now going to make a huge jump – across some 50 degrees of sky – through the star fields of Andromeda to the constellation of Perseus.

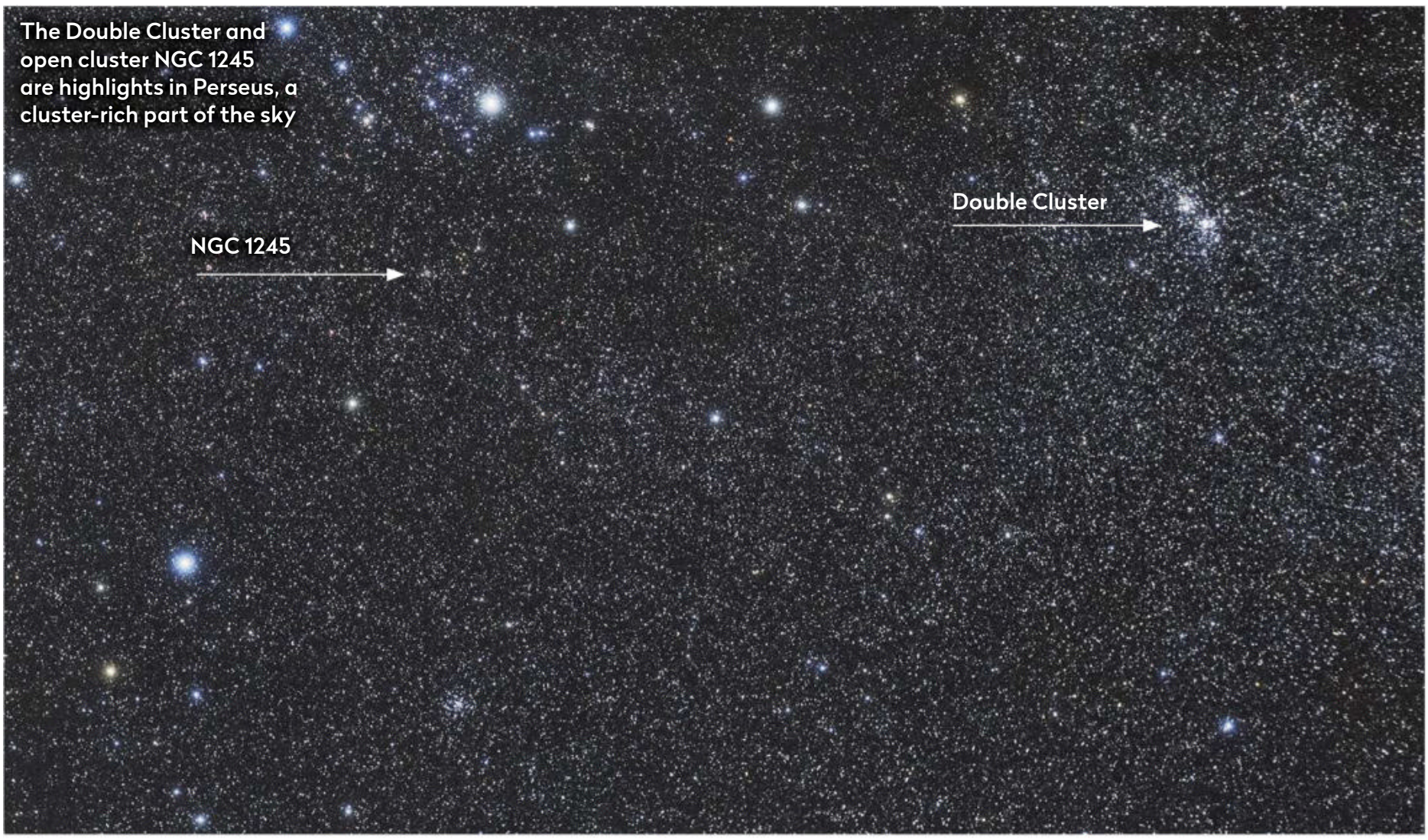
There are so many clusters in this part of the sky that we could focus on, but here we're going to examine an open cluster that sits a little over three degrees away from the bright star Mirfak (Alpha (α) Persei). NGC 1245 lies among a dense backdrop of stars – a medium aperture scope should show it in darkish skies.

The mag. +3 star Kappa (κ) Persei is a good place to start if you're trying to track the cluster down manually. Place it on the western edge of the field of view with an eyepiece of around 20–30x magnification, then edge slightly north about two degrees to bring NGC 1245 into view.



You'll be able to enjoy views of NGC 1245 with a medium aperture telescope

CHART BY PETE LAWRENCE, GÜNTER KERSCHHUBER/CCDGUIDE.COM, WILL GATER X 2



The Double Cluster and open cluster NGC 1245 are highlights in Perseus, a cluster-rich part of the sky

"Good binoculars will bring many of the brighter stars of the clusters into view; in fact there's an argument to be made that this is the best way to enjoy the Double Cluster"


The Ursa Major Moving Group includes some of the stars in the familiar asterism known as The Plough

The Double Cluster

If your skies are dark you may be able to pick out a little fuzzy, grey-ish, patch between the stars of Cassiopeia and Perseus using just your eyes. These are the open clusters NGC 869 and NGC 884, which together make the famous Double Cluster, the penultimate object in our tour.

Good binoculars will bring many of the brighter stars of the clusters into view; in fact there's an argument to be made that this is the best way to enjoy this pairing, with the clusters sitting against a magnificent star-flecked background, where the Milky Way runs through this part of the sky. If you're observing the clusters with a telescope, certainly try a low-power eyepiece first – to get that wonderful 'floating in space' feel – before you dive in for a higher magnification look.

Stars in Ursa Major

Our last star cluster is something a bit different to the others in our guide. You won't need a scope or a pair of binoculars. You'll be able to use just your eyes to see some of its members – though this cluster probably won't look like what you're imaging. To see it, just look north towards Ursa Major. That's because a number of the stars in this part of the sky – including the naked-eye stars Merak (Beta (β)), Alioth (Epsilon (ε)) and Megrez (Delta (δ) Ursae Majoris) are actually part of a collection known to astronomers as the Ursa Major Moving Group. Some scientists believe these stars formed together as a cluster but are now disbanding as they move through the Milky Way!

Will Gater is an astronomy journalist and science presenter. His latest book, *The Mysteries of the Universe*, has just been published by DK

BBC Sky at Night MAGAZINE

16-PAGE CENTRE PULLOUT

The Sky Guide

NOVEMBER 2020

LUNAR HIDE AND SEEK

Observe the waning gibbous Moon as it occults the southern region of the open cluster M35

TWIN PEAKS

Get the best views of the Northern Taurid and Leonid meteor showers

DISTANT PURSUIT

How to spot the planet Uranus with the naked eye

PETE LAWRENCE

About the writers

Astronomy expert **Pete Lawrence** is a skilled astro imager and a presenter on *The Sky at Night* monthly on BBC Four

Steve Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 54

Also on view this month...

- ✦ Asteroid 8 Flora reaches opposition
- ✦ Get to know the Moon's clair-obscur effects
- ✦ The Pleaides reaches its highest point in the sky

Red light friendly

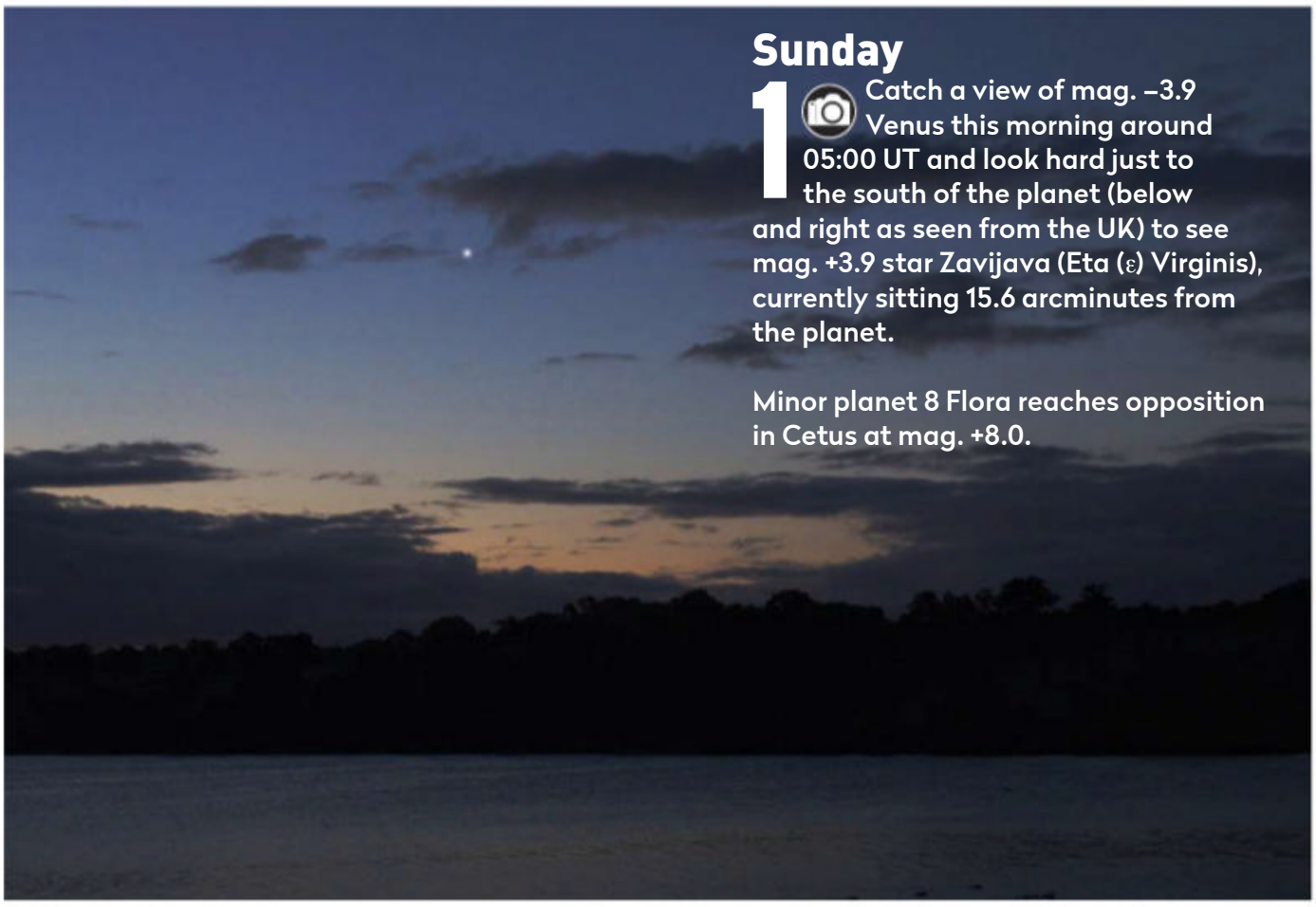
To preserve your night vision, this Sky Guide can be read using a red light under dark skies

Get the Sky Guide weekly

For weekly updates on what to look out for in the night sky and more, sign up to our newsletter at **www.skyatnightmagazine.com**

NOVEMBER HIGHLIGHTS

Your guide to the night sky this month



Sunday 1

Catch a view of mag. –3.9 Venus this morning around 05:00 UT and look hard just to the south of the planet (below and right as seen from the UK) to see mag. +3.9 star Zavijava (Eta (ε) Virginis), currently sitting 15.6 arcminutes from the planet.

Minor planet 8 Flora reaches opposition in Cetus at mag. +8.0.

Tuesday 3

Jupiter and Saturn now appear less than 5° apart in the early evening sky.

Monday 9

This morning presents an opportunity to spot the rare clair-obscur effect known as the Curtiss Cross. The cross is formed from relief features near to the 6km-crater Frau Mauro H.

Friday 13

Catch mag. –3.9 Venus near a slender 5%-lit waning crescent Moon this morning. Both objects will be well presented from around 05:00 UT onwards, low in the east-southeast. Mag. –0.6 Mercury joins the party later, rising around 05:30 UT.

Saturday 14 ▶

With the Moon out of the way this is a great time to try our 'Deep Sky Tour' on page 56, which looks at objects around the foot of Perseus, the Greek Hero.

Tuesday 17

The annual Leonid meteor shower reaches its peak this evening. As the Moon is just two days old, the conditions for viewing these swift meteors are good.

Wednesday 18

Look towards the southwest as the sky darkens to see mag. +0.9 Saturn, mag. –1.9 Jupiter and a 16%-lit waxing crescent Moon close together. Saturn and Jupiter are separated by just 3.5°, the Moon being 10° west of Jupiter.

Family stargazing

The Andromeda Galaxy, M31, is a distant galaxy which can be seen with the naked eye. First, identify the Great Square of Pegasus using our main chart on page 50. Next, extend the top edge of the square left by the same length, bending up slightly to locate a star that's a similar brightness to the square's stars. Then turn 90°, heading up the sky to a dimmer star. Keep going for an even dimmer star and M31 lies next to this, appearing like an elongated fuzzy patch. If your young observers can spot it, tell them that the light they are seeing left M31 2.5 million years ago! **www.bbc.co.uk/cbeebies/shows/stargazing**

Sunday 22 ▶

The lunar X and V clair-obscur effects are visible in daylight hours, reaching a peak after 14:00 UT.

Later, in darkness, use a high magnification on crater Albategnius to see the clair-obscur effect known as the Face in Albategnius.

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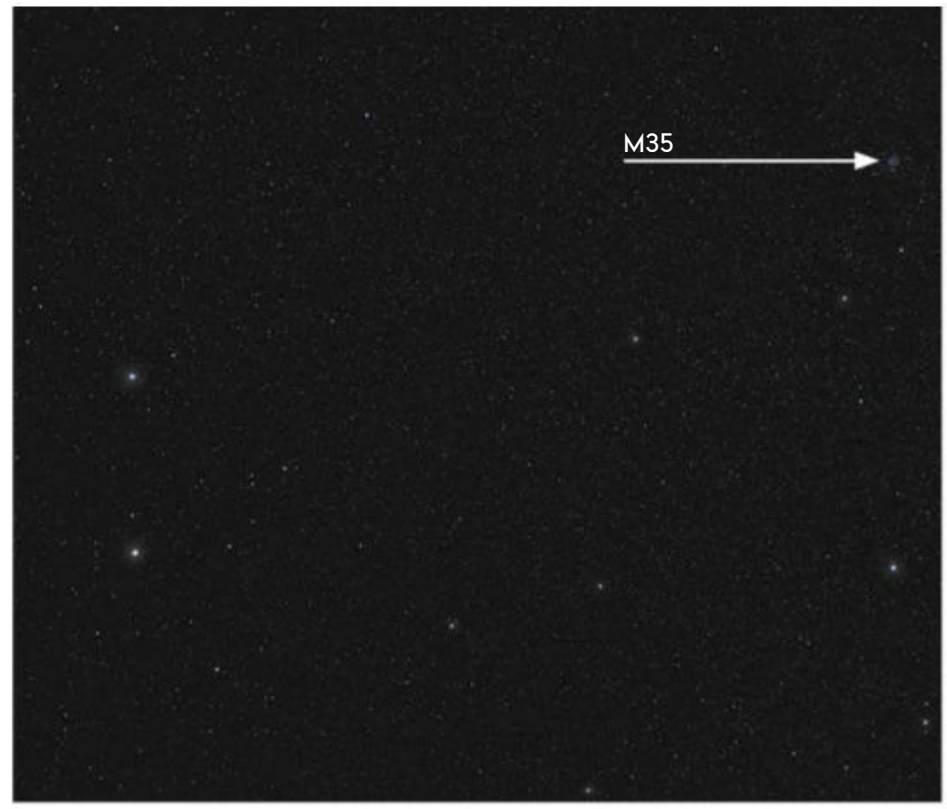


Thursday ▶
5 Starting just after 01:00 UT, the 82%-lit waning gibbous Moon will begin to move in front of the southern part of the open cluster M35 in Gemini.

Tuesday
10 Mercury reaches greatest western elongation, 19.1° from the Sun. The mag. –0.4 planet is visible in the morning sky, rising two hours before the Sun and visible above the east-southeast horizon.

Wednesday
11 Despite being dim at mag. +14.1, the dwarf planet Pluto is conveniently positioned near the gas giant Jupiter. This evening, both planets are just 42 arcminutes apart.

Thursday
12 Today is the peak of the Northern Taurid meteor shower; its ZHR (zenithal hourly rate) is low at 5 meteors per hour, but it does have a broad peak.

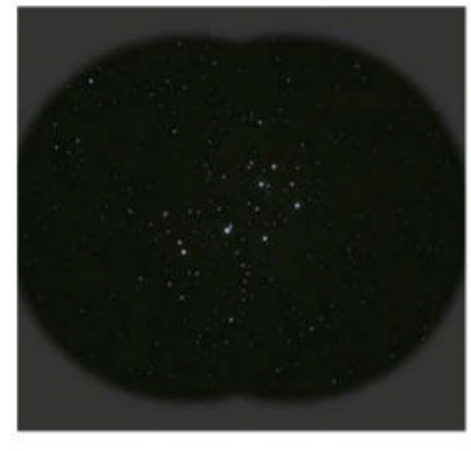
Mag. –3.9 Venus sits 1.3 arcminutes from mag. +4.4 Theta (θ) Virginis at 05:50 UT.

Sunday
15 The weak Iota Aurigid meteor shower reaches a peak with a ZHR (zenithal hourly rate) of 8.2 meteors per hour. A new Moon provides a great opportunity to view this less familiar shower.

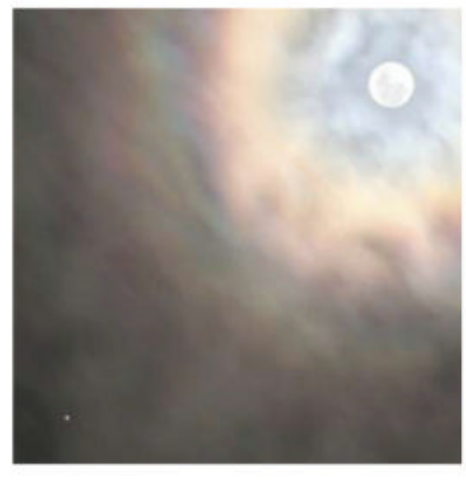
◀ Monday
16 Mag. –1.6 Mars reaches a stationary point today, as its previous western motion against the background stars comes to a halt. After today, the planet's motion resumes, this time east against the background sky.

Thursday
19 This evening, the 25%-lit waxing crescent Moon is arranged with Saturn and Jupiter to form a right-angled triangle, with Saturn at the right angle.

Friday ▶
20 The beautiful Pleiades open cluster reaches its highest position in the sky, due south at midnight. Its a superb object to explore with binoculars – a reclining garden chair will give you the most comfortable experience.



Thursday ▶
26 Mag. –1.3 Mars and an 83%-lit waxing gibbous Moon sit 4.9° from one another in the early hours.



Monday
30 Today's full Moon occurs close to the furthest point in its orbit from Earth, known as apogee (27 November). As a result, the full Moon will appear smaller and dimmer than average – the effect is known as a 'micromoon'!

NEED TO KNOW

The terms and symbols used in The Sky Guide

Universal time (UT) and British Summer Time (BST)
Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT

RA (Right ascension) and dec. (declination)
These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'

Family friendly
Objects marked with this icon are perfect for showing to children

Naked eye
Allow 20 minutes for your eyes to become dark-adapted

Photo opp
Use a CCD, planetary camera or standard DSLR

Binoculars
10x50 recommended

Small/ medium scope
Reflector/SCT under 6 inches, refractor under 4 inches

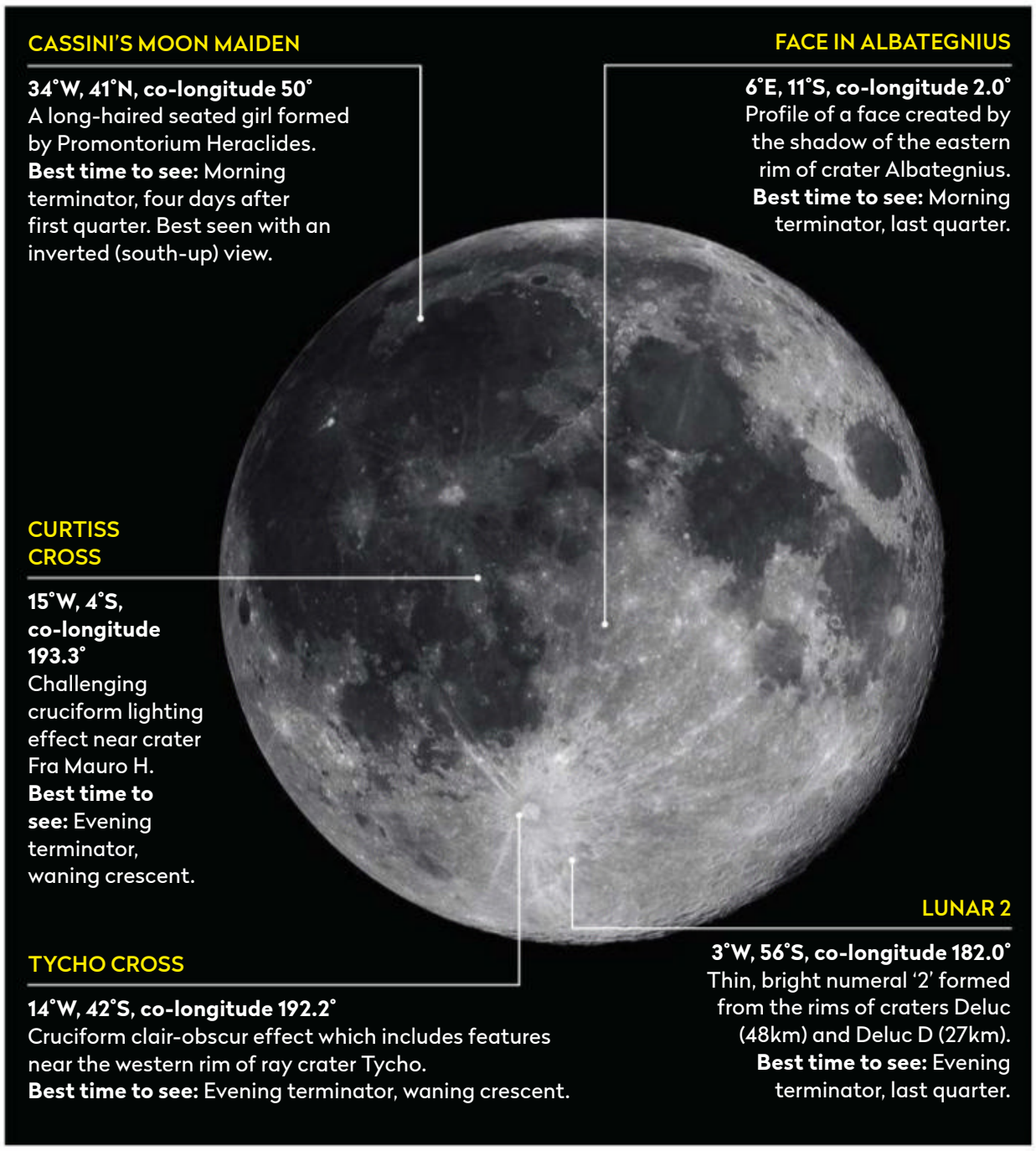
Large scope
Reflector/SCT over 6 inches, refractor over 4 inches

GETTING STARTED IN ASTRONOMY

If you're new to astronomy, you'll find two essential reads on our website. Visit **http://bit.ly/10_easylessons** for our 10-step guide to getting started and **http://bit.ly/buy_scope** for advice on choosing a scope

THE BIG THREE

The three top sights to observe or image this month



◄ Tricks of the light: look out for this month's clair-obscur effects, caused by sunlight on the Moon's surface

framing for reappearances only, positioning your telescope so only the dark, night-side portion of the Moon is in the field of view.

A number of interesting clair-obscur events also take place this month, some of which are less common than the usual fare. In the early hours of 8 November, it should be possible to see the Lunar 2 – a thin, casually written '2' formed by sunlight on the rims of craters Deluc and Deluc D – at 02:45 UT (co-longitude 182.0°).

Then on the night of 8/9 November, two crosses should be visible. The first is known as the Tycho Cross and is formed by features in the vicinity of the western ring of Tycho, near moonrise at 22:45 UT (co-longitude 192.2°). Later, the Curtiss Cross forms as the Sun sets over the Fra Mauro Zeta ridge complex, 90km northeast of Fra Mauro's centre at 01:00 UT (co-longitude 193.3°). On the 22nd, just after 22:00 UT (co-longitude 2°), look for the Face in Abategnius: use a high magnification on crater Albategnius, where you should be able to see the shadow of the crater's eastern rim on its floor. See if you can make out the profile of a face there.

Finally, an easy clair-obscur is visible on 26 November. Look at the Bay of Rainbows or Sinus Iridum, located on the northwest shore of Mare Imbrium. The southern end of the Jura mountains peters out here in the Promontorium Heraclides. At 20:40 UT (co-longitude 50.0°) an inverted scope view of this feature should reveal the profile of a girl with billowing hair; this is Cassini's Moon Maiden.

DON'T MISS

NOVEMBER MOON EVENTS

BEST TIME TO SEE:
As stated, 5 November 01:20–03:00 UT for the M35 occultation

The Moon puts on a good show this month. Beginning on the morning of 5 November, an 82%-lit waning gibbous Moon passes in front of the southern part of the rich open cluster M35, in Gemini. Although the bright Moon will drown out the fainter stars, a scope trained on the Moon's northern limb should show the brighter cluster members. The Moon's bright limb leads the occultation, hiding the cluster's outer stars from 01:20 UT. From around 01:50 UT it should be possible to see stars reappearing from behind the Moon's dark limb, with the occultation ending around 03:00 UT. If you find yourself struggling with the brightness of the illuminated portion of the Moon, try

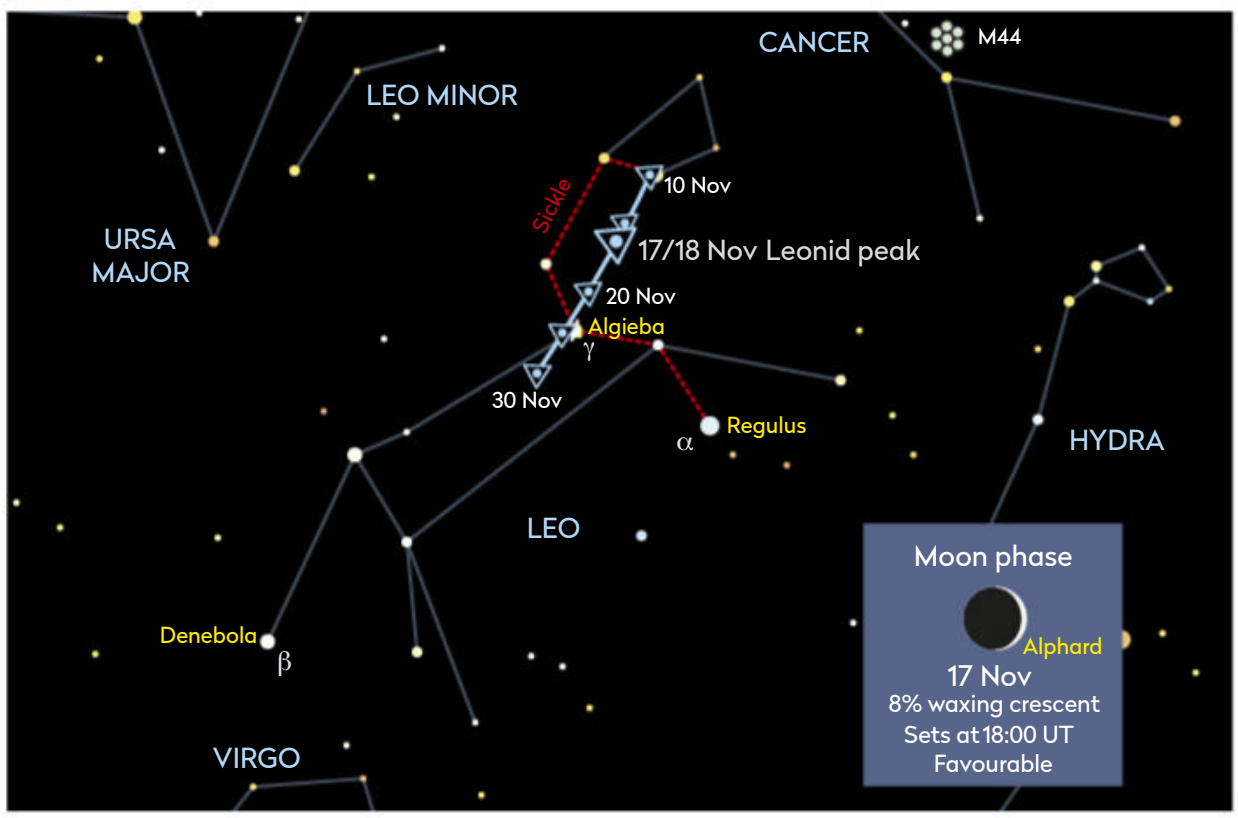
A photographic simulation of the Moon passing across the southern part of open cluster M35 on 5 November

ALL PICTURES: PETE LAWRENCE

Leonid meteor shower 2020

BEST TIME TO SEE: In the morning, 17 and 18 November

▼ **The radiant of the Leonids is located in Leo, in the Sickle asterism**



The annual Leonid meteor shower reaches its peak activity at 11:00 UT on 17 November with a ZHR (zenithal hourly rate) estimated to be somewhere in the range of 10–20 meteors per hour. This peak time is obviously in daylight, but there are also some interesting predictions for dust trail crossings at periods that will be in darkness for UK viewing.

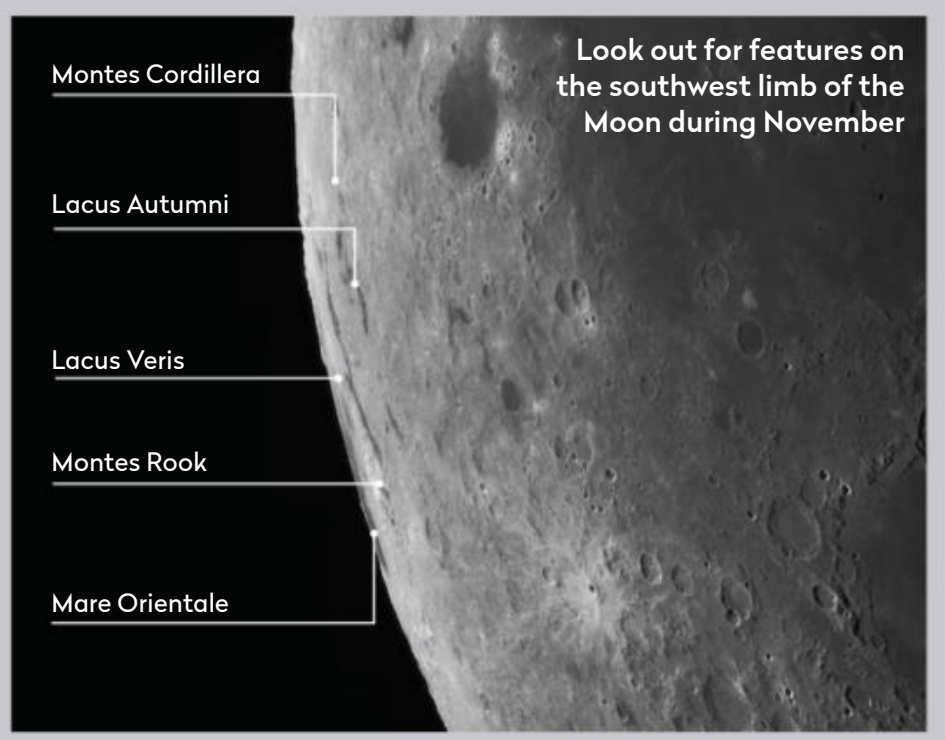
Generally, the Leonids are best observed after midnight and technically they should be putting on their best show during the morning of 17 November from 00:00 UT until the onset of dawn, around 05:40 UT. A watch on the morning of 18 November should still produce results, but is further from the predicted ZHR peak of 11:00 UT than the morning session on the 17th. An added bonus is that this year's new Moon is out of the way for the peak period.

Although there's a prediction of enhanced activity from 06:50 UT until 08:13 UT on the morning of 17 November, it's expected that this will consist mostly of faint meteor trails. It's also when the sky will be bright with morning twilight from the UK. A second period of enhancement may occur during darkness in the early morning of 18 November at 00:58 UT. However, it's not expected that these predictions are going to produce significant rate increases as the trails which are responsible for them will have spread over time and will have become sparse.

Leonid meteors can typically be seen between 10–20 November; they are fast meteors, associated with the debris stream of comet 55P/Tempel-Tuttle. The radiant is located within the curved portion of the Sickle asterism in Leo, the pattern that is meant to represent the Lion's head.

A favourable southwest libration

BEST TIME TO SEE: Mornings of 5–12 November.



Look out for features on the southwest limb of the Moon during November

The Moon's globe appears to face the same way towards our planet because it's gravitationally locked to Earth. However, the fact that its orbit around Earth is elliptical and tilted slightly means it appears to rock and roll slightly over time, an effect known as libration.

If the Moon faced Earth strictly with no variation, we'd only be able to see 50 per cent of its face, but libration allows us to see a bit extra, in total 59 per cent of the Moon's surface over time. Between 5–12 November, libration favours the Moon's southwestern limb and here there is a fantastic feature to look out for. Hidden from view most of the time, it's a 1,000km-diameter concentric ring basin centred on Mare Orientale.

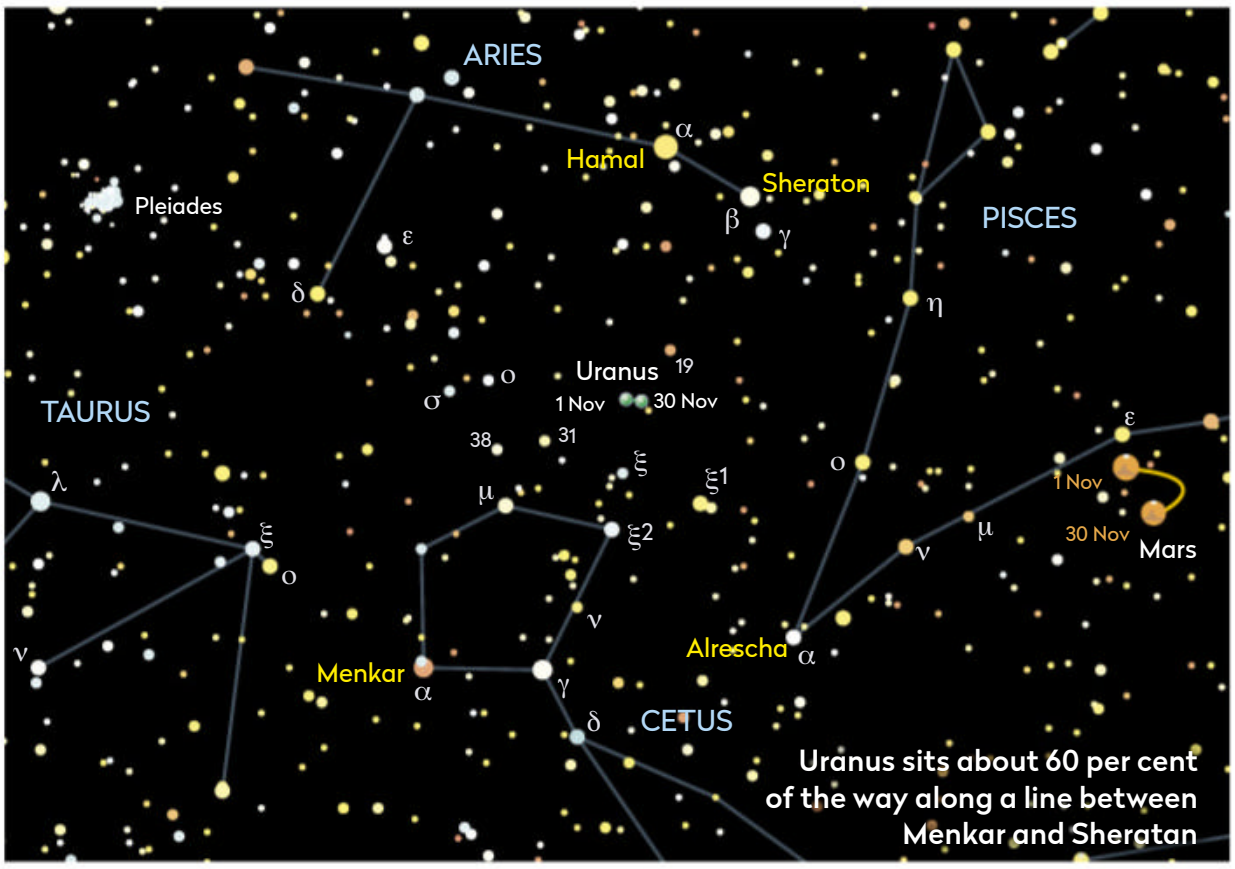
A spacecraft's view from directly overhead would reveal an impressive 'bull's eye' impact basin, the rings of the bull's eye delineated by mountain ranges. Interspersed between them are dark lava lakes.

From Earth, we can only get a tantalising glimpse of the 300km Mare Orientale, extremely foreshortened to make feature identification that much harder. The best views will be during the mornings of 5–12 November as the Moon moves into its waning phases prior to new Moon on 15 November.

PICK OF THE MONTH

Uranus

Best time to see: 1 November, 23:50 UT
Altitude: 51°
Location: Aries
Direction: South
Features: Small greenish disc, brighter moons
Recommended equipment: 150mm or larger



Uranus was at opposition on 31 October and remains well placed for UK viewing throughout November and December. While opposition marks a big change in the appearance of a close planet like Mars, for the distant ice giants Uranus and Neptune, the difference is small.

Easily seen though binoculars, the tricky aspect of identifying Uranus currently comes from its location in southern Aries where there aren't many stars to signpost it. One way to locate its general area is to identify Menkar (Alpha (α) Ceti) and Sheratan (Beta (β) Arietis); Uranus lies 60 per cent of the way along this line, starting at Menkar. Through binoculars, Uranus looks like a mag. +5.7 star, which again isn't particularly helpful as there are other stars of similar brightness in the area.

A small telescope is the minimum you need to bring out the amazing colour of the planet, and this is the best way to positively identify it through the eyepiece. Uranus currently presents a 3.8 arcsecond disc, which can be seen with a small scope, while larger instruments will show this disc very clearly. An interesting challenge for large aperture telescope owners, or those with planetary imaging setups, is to try and record the brighter moons of Uranus: Miranda (mag. +16.5), Ariel (+14.3), Umbriel (15.0), Titania (+13.9) and Oberon (+14.1).

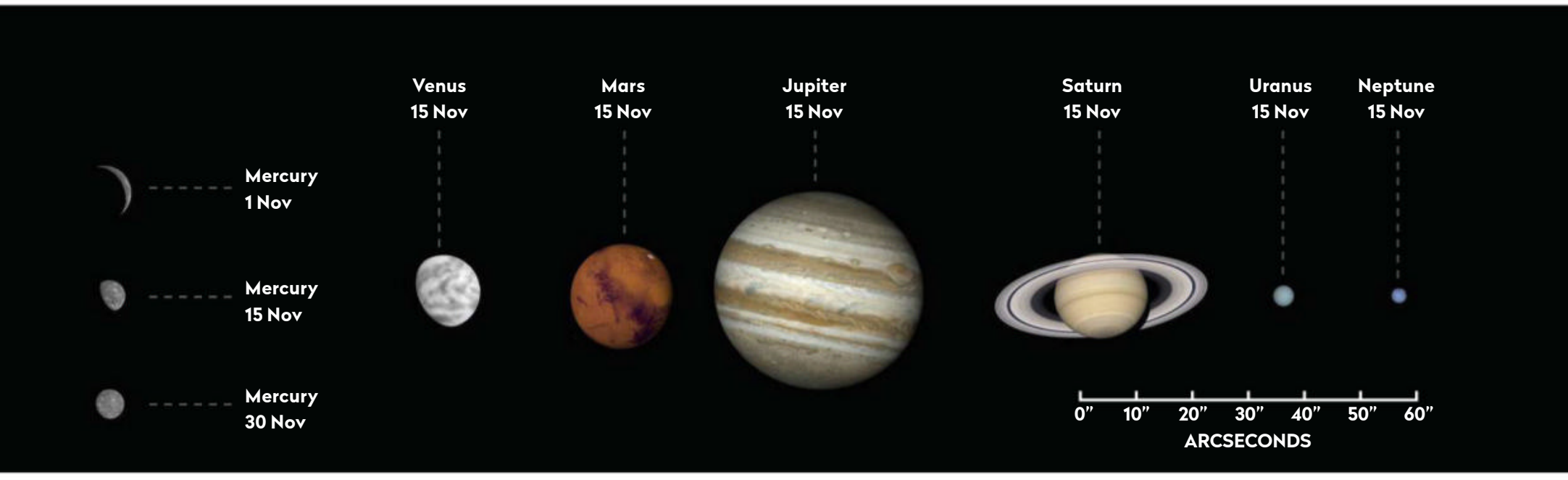
▲ **See if you can image the brighter moons of Uranus this month**

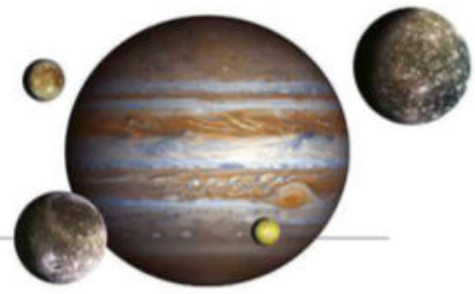
Although its disc is small, imaging setups have recorded features on the planet in the past. These normally consist of bands in the planet's atmosphere but additionally, 'hot-spot' bright regions have been recorded too: huge storms within the planet's atmosphere. Filters are typically used to reveal detail like this, popular choices being IR 685 or RG610 filters, combined with a camera that is particularly sensitive to red and infrared light.

PETE LAWRENCE X 3

The planets in November

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope





Mercury

Best time to see: 10 November, from 06:00 UT
Altitude: 3.5° (low)
Location: Virgo
Direction: East-southeast
Mercury is a morning object all month; on 1 November it's at mag. +1.5 and rises over the east-southeast horizon 70 minutes before the Sun. It brightens to reach mag. –0.4 on the 10th when it's at greatest western elongation (19.1° W) rising two hours before the Sun. Neptune maintains a good brightness, shining at mag. –0.7 on the 30th and rising an hour before sunrise.

Venus

Best time to see: 1 November, 05:30 UT
Altitude: 14°
Location: Virgo
Direction: East-southeast
Venus is creeping closer to the Sun in the morning sky. Despite this it remains prominent during November. On the 1st, mag. –3.9 Venus rises 3.5 hours before the Sun, a telescope revealing its phase to be 81% with an apparent size of 13 arcseconds. By the end of the month it rises 2 hours and 40 minutes before the Sun and shows an 88%-lit disc, 11 arcseconds across through a telescope eyepiece. On the 13th, it's grouped with a 5%-lit waning crescent Moon and mag. –0.6 Mercury.

Mars

Best time to see: 1 November, 22:30 UT
Altitude: 42°
Location: Pisces
Direction: South
Mars was at opposition on 13 October and remains bright through November, but dims from mag. –2.1 on the 1st to mag. –1.1 on the 30th. The planet reaches a stationary point in the sky on the 16th when its apparent movement changes from westward to eastward. It remains bright but dimming, with a 20 arcsecond disc on the 1st, shrinking to 15 arcseconds by the 30th.

Jupiter

Best time to see: 1 November, 17:45 UT
Altitude: 14°
Location: Sagittarius
Direction: Just west of south
Jupiter is visible all month in the evening sky, to the west of south as darkness falls. Shining around mag. –2.0 it appears close to Saturn. Both planets start to converge noticeably this month, their separation reducing from just over 5° at the start to 2.3° by the month's end.

Saturn

Best time to see: 1 November, 17:45 UT
Altitude: 15.5°
Location: Sagittarius
Direction: Just west of south
Saturn shines just to the east of Jupiter, currently at mag. +0.9, with both planets converging towards the month's end ahead of December's Great Conjunction. A 25%-lit waxing crescent Moon forms a right-angled triangle with Jupiter and Saturn on the 19th.

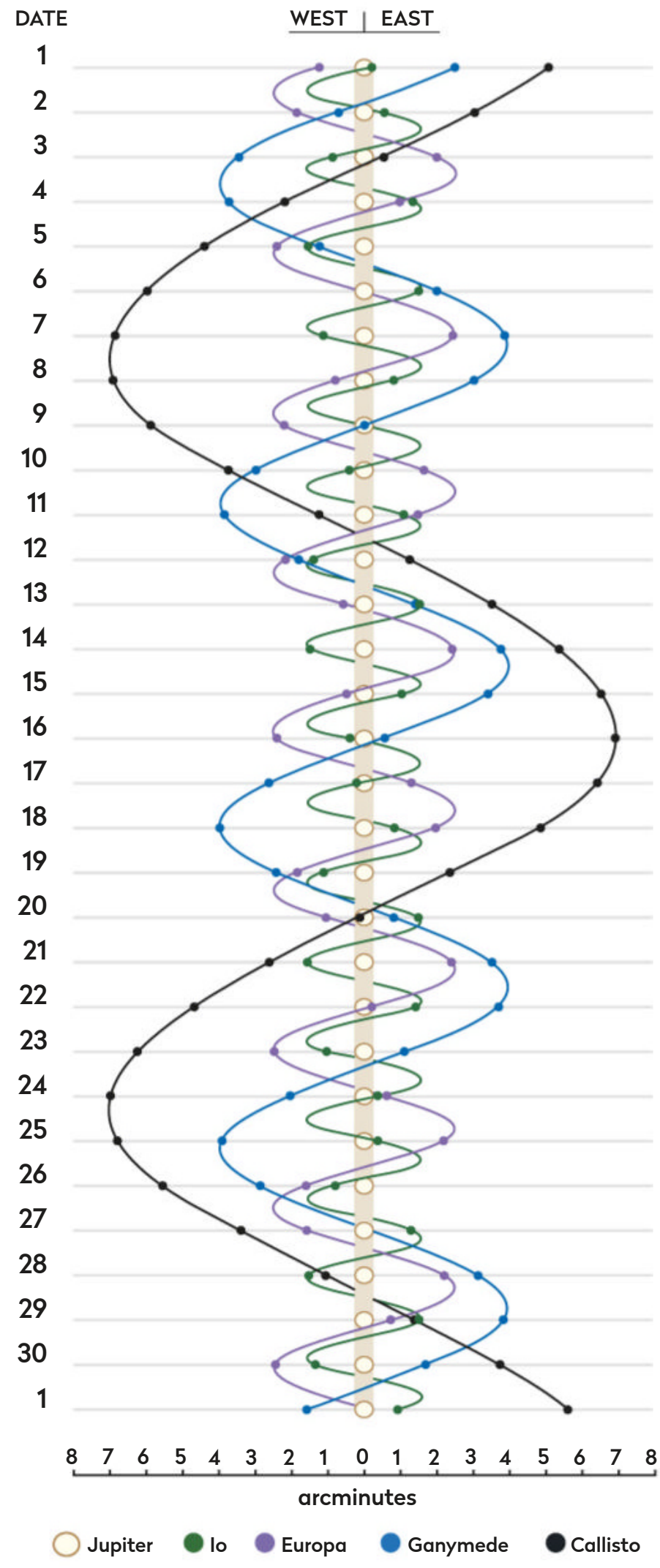
Neptune

Best time to see: 1 November, 20:50 UT
Altitude: 31°
Location: Aquarius
Direction: South
Neptune is well placed in the evening sky, just to the east of Phi (ψ) Aquarii. It shines at mag. +7.8, so you'll need at least binoculars to see it. It passes its highest point in the sky, due south, in darkness all month and appears to nudge west towards Phi Aquarii.

More **ONLINE**
Print out observing forms for recording planetary events

JUPITER'S MOONS: NOV

Using a small scope you can spot Jupiter's biggest moons. Their positions change dramatically during the month, as shown on the diagram. The line by each date represents 00:00 UT.



THE NIGHT SKY – NOVEMBER

Explore the celestial sphere with our Northern Hemisphere all-sky chart

KEY TO STAR CHARTS

- Arcturus — STAR NAME
- PERSEUS — CONSTELLATION NAME
- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- THE MOON, SHOWING PHASE
- COMET TRACK
- ASTEROID TRACK
- STAR-HOPPING PATH
- METEOR RADIANT
- Circlet — ASTERISM
- PLANET
- QUASAR

STAR BRIGHTNESS:

- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER
- COMPASS AND FIELD OF VIEW
- MILKY WAY

CHART: PETE LAWRENCE

When to use this chart

1 November at 00:00 UT
15 November at 23:00 UT
30 November at 22:00 UT

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

How to use this chart

1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.

Sunrise/sunset in November*

Date	Sunrise	Sunset
1 Nov 2020	07:10 UT	16:37 UT
11 Nov 2020	07:29 UT	16:19 UT
21 Nov 2020	07:47 UT	16:05 UT
01 Dec 2020	08:03 UT	15:55 UT

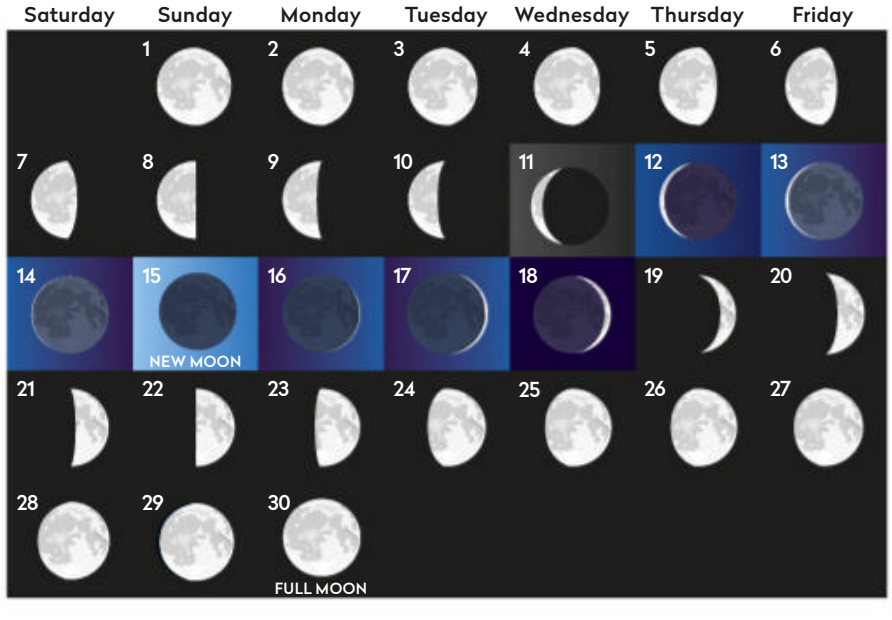
Moonrise in November*

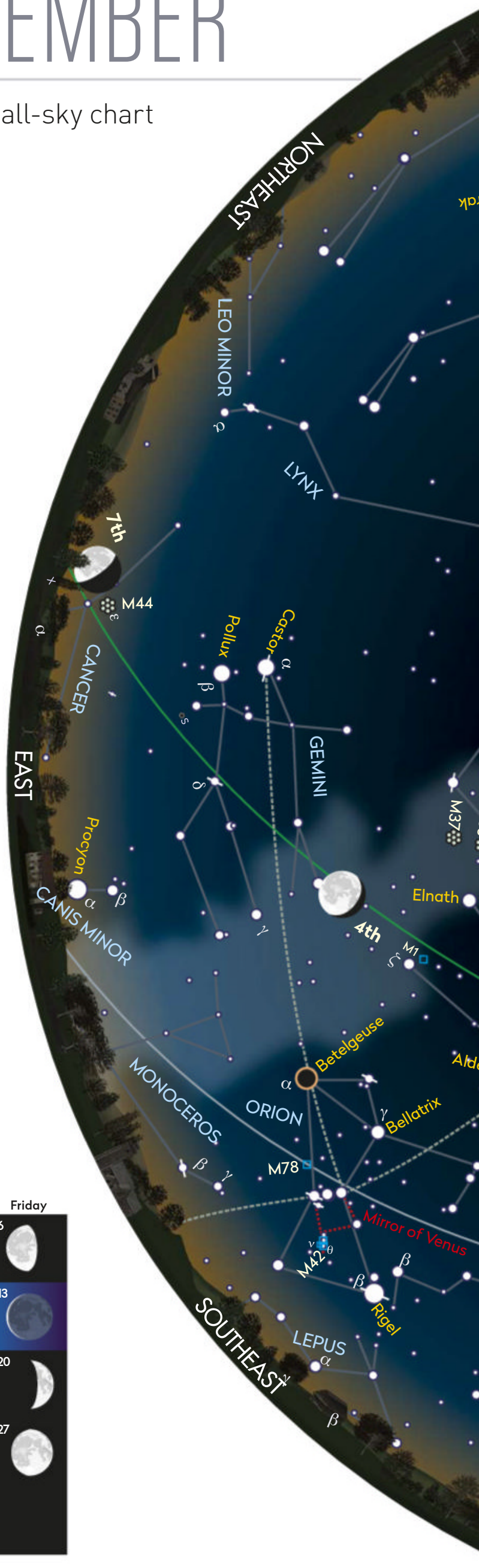
Moonrise times

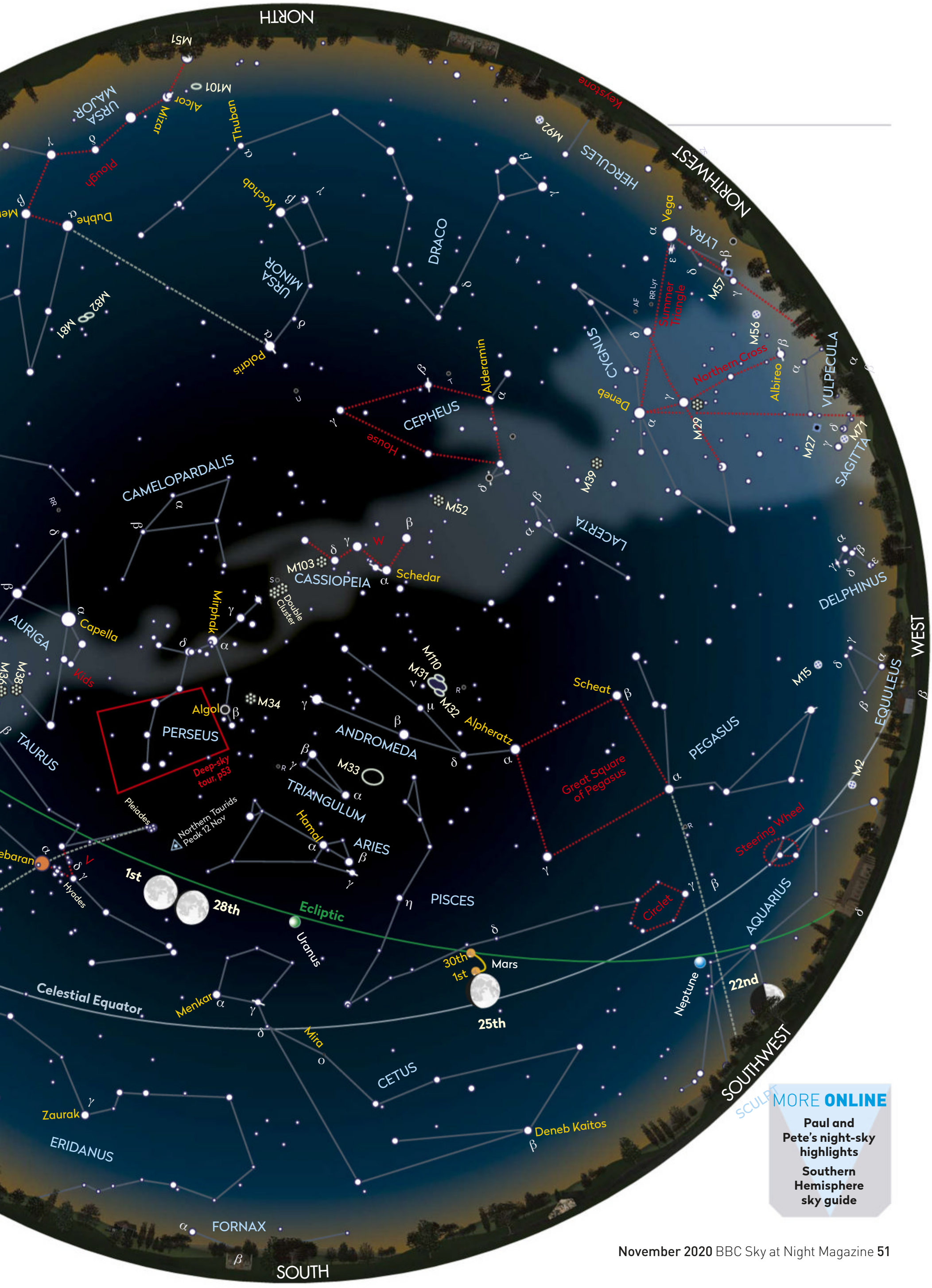
1 Nov 2020, 17:15 UT	17 Nov 2020, 10:35 UT
5 Nov 2020, 19:24 UT	21 Nov 2020, 13:40 UT
9 Nov 2020, --:-- UT	25 Nov 2020, 14:41 UT
13 Nov 2020, 04:36 UT	29 Nov 2020, 15:41 UT

*Times correct for the centre of the UK

Lunar phases in November







MORE **ONLINE**

Paul and Pete's night-sky highlights

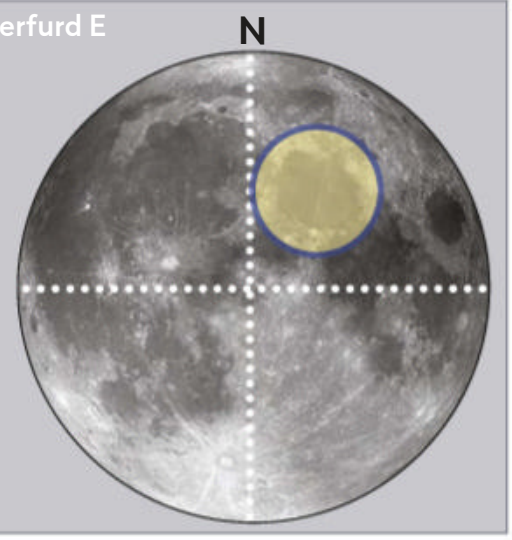
Southern Hemisphere sky guide

MOONWATCH

November's top lunar feature to observe

Mare Serenitatis

Type: Lunar Sea
Size: 650km
Longitude/latitude: 18.4° E, 27.3° N
Age: 3.9 billion years
Best time to see: Five days after new Moon (20–22 November) and four days after full Moon (5–7 November)
Minimum equipment: Naked eye

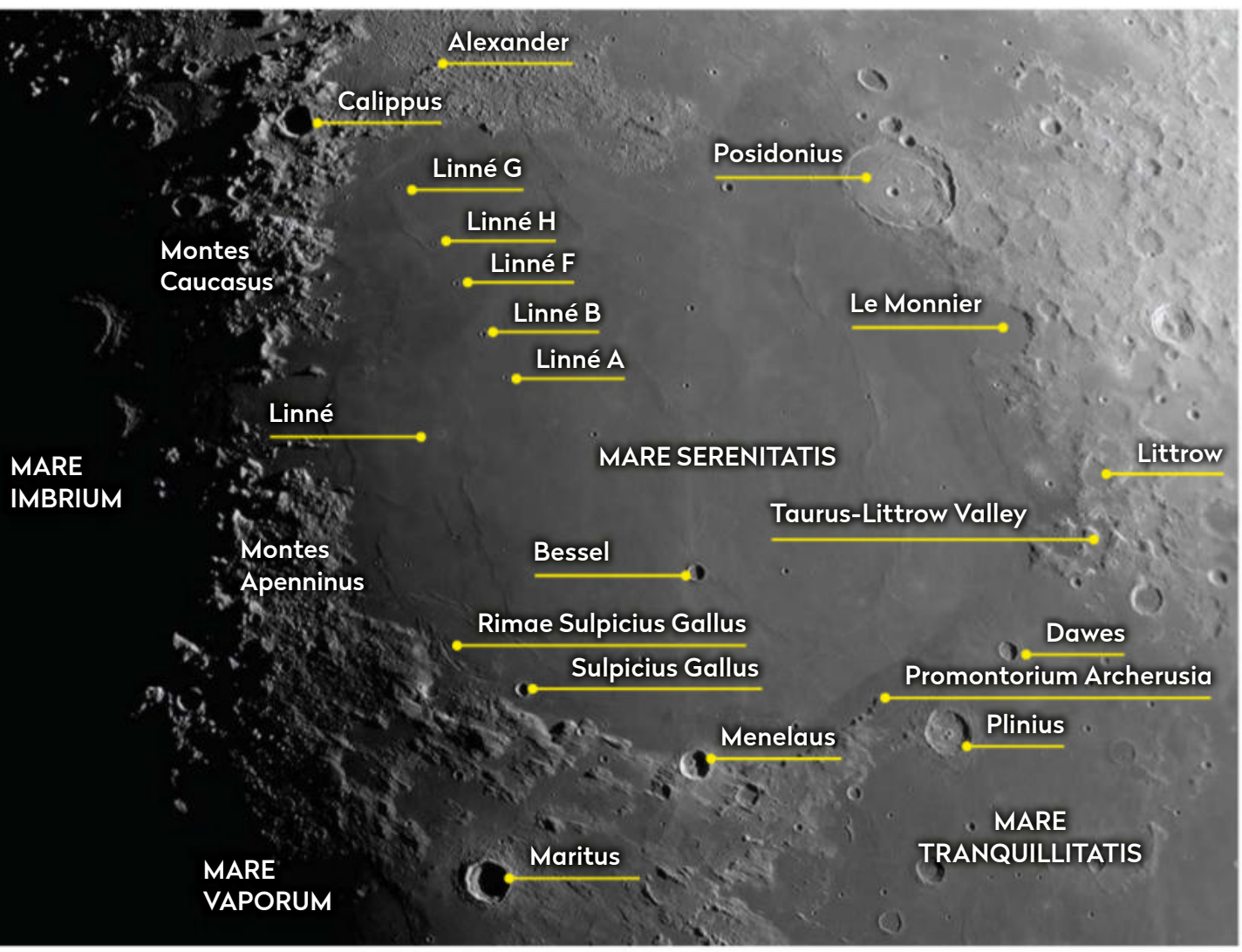


Mare Serenitatis is one of the primary dark lava seas on the Earth-facing side of the Moon. The 'Sea of Serenity' makes a good pair with neighbouring 700km **Mare Tranquillitatis**, the 'Sea of Tranquillity'. Serenitatis is roughly circular and sits between Mare Imbrium to the west and Mare Tranquillitatis to the southeast. Less well defined to the southwest is Mare Vaporum. To the northeast Serenitatis overspills into an irregular region north of 96km **Posidonius**, a crater which appears to have an inner floor tilted up in the east. South of Posidonius is the dark, circular but broken form of 61km **Le Monnier**, resembling a less impressive version of the 400km x 260km Sinus Iridum, the 'Bay of Rainbows', located on the northwest shore of 1,250km **Mare Imbrium**. Le Monnier is a crater infilled with lava from Mare Serenitatis.

PETE LAWRENCE X 3

The Taurus-Littrow Valley marks the location of the Apollo 17 landing site

▼ Mare Serenitatis, the 'Sea of Serenity', is smooth and almost circular in appearance



South of Le Monnier lies a complex area around 31km **Littrow**, which consists of elevated highlands interspersed with flat, lowland lava. The 30km **Taurus-Littrow Valley** is in the region south of Littrow, marking the location of the last human presence on the Moon, the Apollo 17 landing site.

Continuing south brings us to the border between Mare Serenitatis and Mare Tranquillitatis. A strong contrast between the darker lava of Tranquillitatis and the lighter material of Serenitatis is very apparent here, with the latter being the younger of the two maria.

The craters **Dawes** (18km) and **Plinius** (43km) are all that sit in the 200km-wide region where Serenitatis meets Tranquillitatis. The western end of the gap is terminated by a pointed feature known as **Promontorium Archerusia**, arcing toward 27km crater **Menelaus**. Running across Serenitatis's surface, north-northeast through 17km **Bessel**, is a bright ejecta ray from 86km crater **Tycho**, located 2,000km south-southwest.

If we continue northwest around Serenitatis's border we come to 12km **Sulpicius Gallus**, a crater marking the start of an impressive set of rilles, or narrow channels, expanding like the branches of a tree northwest. The rilles are known as **Rimae Sulpicius Gallus**.

Approaching the border with Mare Imbrium, we first pass the foothills of the Apennine mountains to the west. The seas join where a 75km gap sits between **Montes Apenninus** to the south and **Montes Caucasus** to the north. The Caucasus range continues north, a round hilly area to the east of the 33km crater **Calippus** marking Serenitatis's northern border.

A curiosity is visible just south of where Montes Caucasus merges with the hilly region, running south of the eroded 82km crater **Alexander**. Here you'll find a 210km linear arrangement of small craters. Starting at 5km **Linné G** to the north, head south past 3km **Linné H**, 5km **Linné F**, 5km **Linné B** and 4km **Linné A**.

Next, we travel 80km west-southwest from Linné A to locate the 3km crater **Linné,** which is surrounded by bright ejecta. Once thought to be bowl-shaped, the crater is now known to have the shape of a flattened, inverted cone.

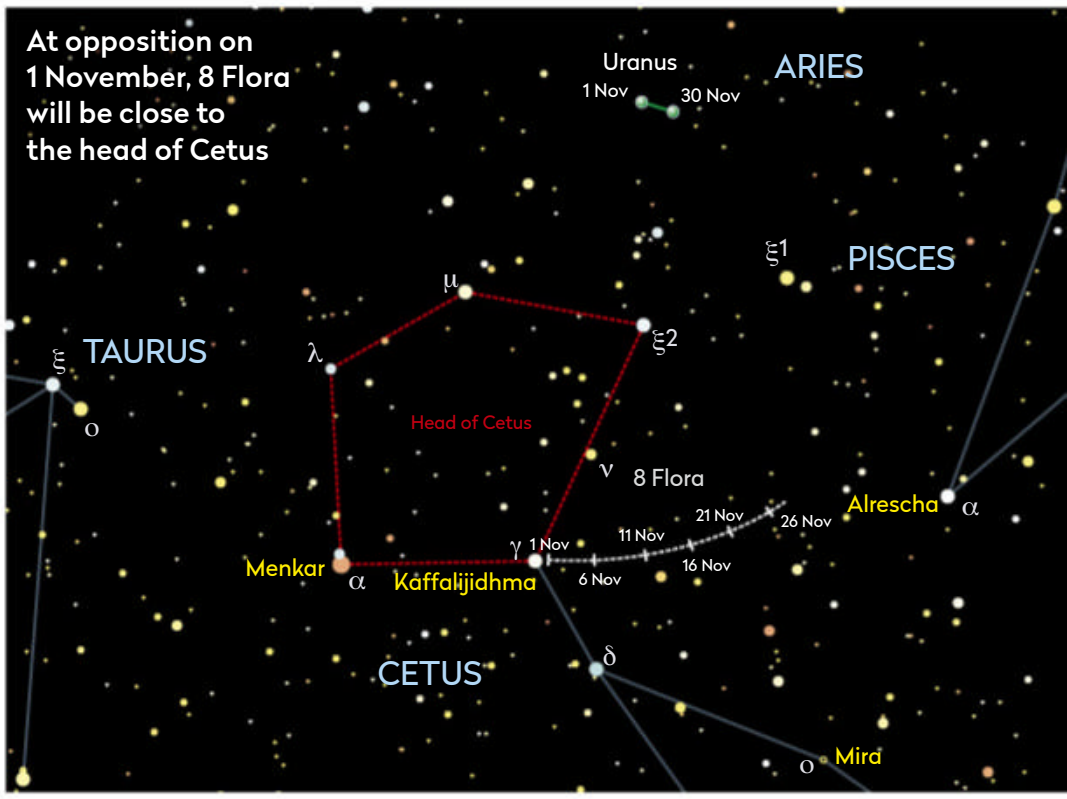
COMETS AND ASTEROIDS

Observe asteroid 8 Flora as it reaches opposition in the constellation of Cetus

The asteroid 8 Flora is at opposition on 1 November, when it will appear at mag. +8.0 in the constellation of Cetus, the Whale. At the start of the month it's conveniently located just to the west of the mag. +3.5 star, Kaffalijidhma (Gamma (γ) Ceti). At 00:00 UT on 1 November the asteroid is just 20 arcminutes west of this star. Kaffalijidhma marks the southern point of Cetus's misshapen pentagonal head. Over the remainder of the month, Flora tracks west, arcing slightly to the west-northwest towards the end of November. It never strays too far from the head asterism though.

Flora is a large and bright object, with a mean diameter of 128km based on tri-axial ellipsoidal dimensions of 136km x 136km x 113km. It has a relatively high albedo of 24.3%, a measure of how much incoming light it reflects. At favourable oppositions it can brighten to mag. +7.9 (at its dimmest it is mag. +11.6) and this month's opposition will see it get close to its peak of achievable brightness.

Flora has several claims to fame: it's the lead member of the Flora family of S-type (siliceous) asteroids, thought to be the source of the object which impacted Earth and wiped out the dinosaurs. It is also the closest of the large asteroids to the Sun and has the second closest mean orbital distance of the main belt asteroids, at 2.20 AU; its orbit takes it between 1.86 AU and 2.55 AU of the Sun.



Flora has caused confusion in the past, when an observation in March 1917 of the 15th magnitude variable star TU Leonis was usurped by 8 Flora. Having been mistaken for the star, it looked as if TU had brightened considerably. As a consequence, Flora was classified incorrectly as a U Geminorum cataclysmic variable. This classification remained until the error was realised in 1995.

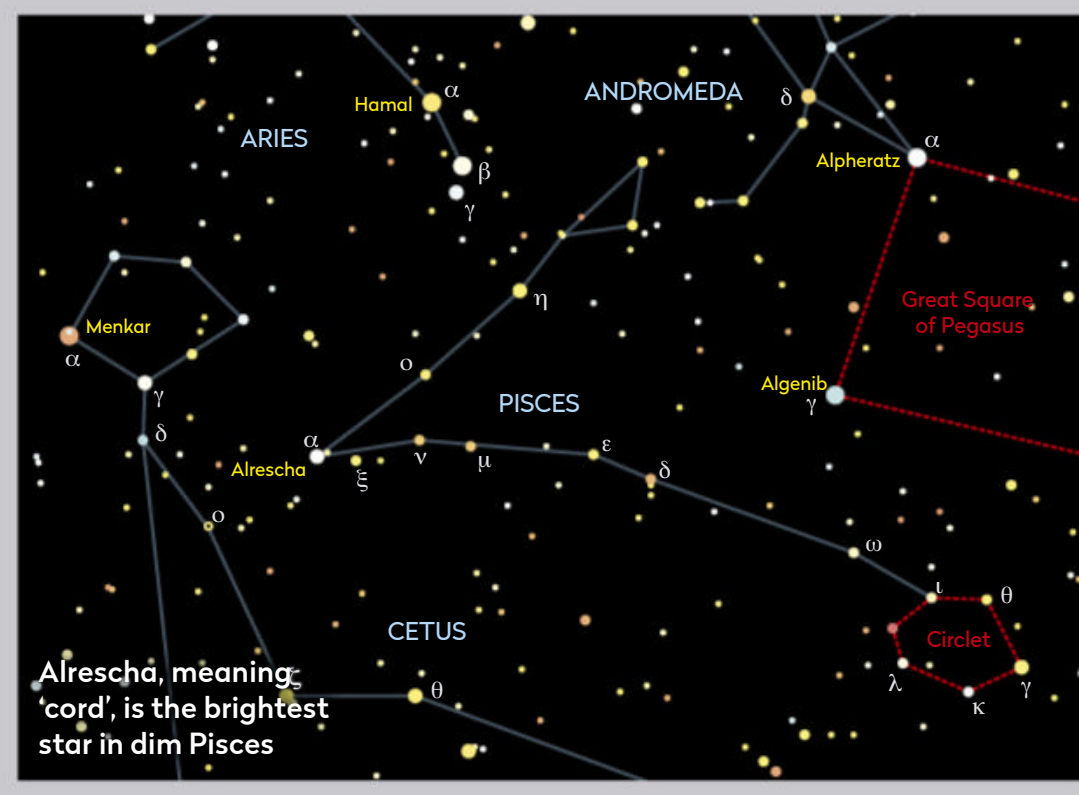
STAR OF THE MONTH

Spot Alrescha, a naked-eye star in Pisces

Alrescha (Alpha (α) Piscium) is the primary star of the faint constellation of Pisces. At mag. +3.8 it's easy to spot with the naked eye under reasonable skies. It lies at a distance of 151 lightyears from the Sun and is a close binary star with an apparent separation between components of just 1.8 arcseconds. Alpha Piscium A is a white star with the spectral type A0p and is mag. +4.3. Alpha Piscium B is also white, being of spectral type A3m and mag. +5.2. The 'p' in Alpha Piscium A's spectral type indicates it has an unspecified peculiarity in its spectrum, which often means it shows an unusual abundance of metals (where 'metal' refers to elements heavier than hydrogen). Indeed, the 'm' in Alpha Piscium B's spectral type indicates its spectrum shows enhanced metals.

Alrescha is a true binary system, with the component stars taking 700 years to complete an orbit around their mutual centre of gravity. As seen from Earth, the two stars will appear closest around 2060. The components are low mass objects, weighing in at 2.3 solar masses for A and 1.8 solar masses for B. Both components outshine our own star by factors of 31 and 12 times respectively.

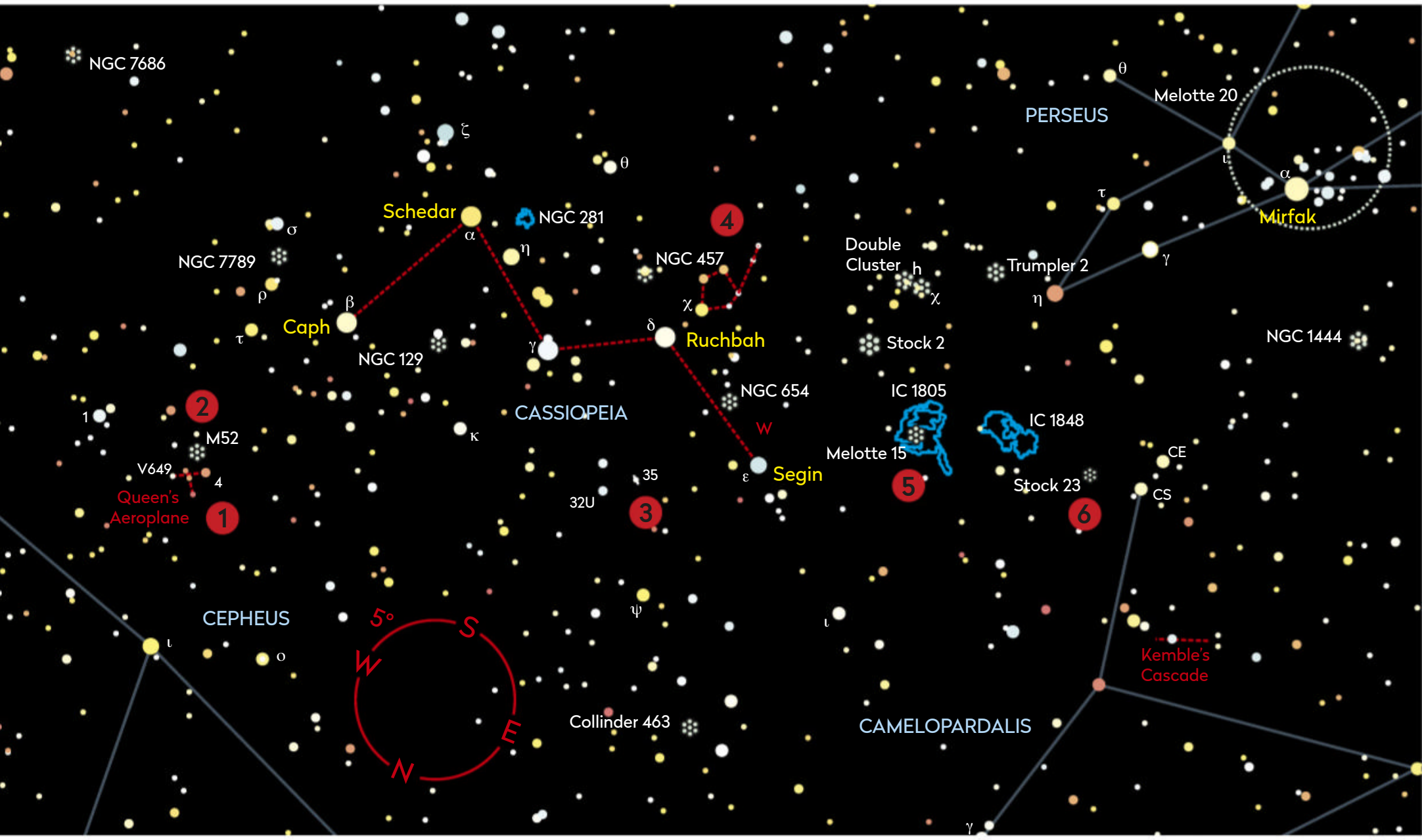
Pisces is supposed to represent two fish tied together with a cord. The fish to the west is represented by a faint but distinctive asterism known as the Circlet, while the fish to the north is pretty obscure. The cord is better defined and appears in two sections running close to the southern and eastern sides of the Great Square of Pegasus. The two sections meet at Alrescha, which means cord.



BINOCULAR TOUR

With Steve Tonkin

Take off with the Queen's Aeroplane and Kite, and enjoy November's wide-field sights



1. The Queen's Aeroplane

10x 50 The golden yellow 4 Cassiopeiae marks the starboard wingtip of a little aeroplane-shaped asterism made of eight stars that shine at mag. +8.0 or brighter. The other wingtip, a degree to the west, is the mag. +6.6 blue-white V649 Cas. The curved 'fuselage' extends to a mag. +6.7 orange-red star, nearly a degree to the north. A dark transparent sky will enable you to appreciate the variety of colours in this star party favourite. ☐ **SEEN IT**

2. M52

15x 70 We'll swap to larger binoculars to get the best of M52, which lies in the same field of view as our first target. You should see about 10 stars resolved against a wedge-shaped grainy glow about 0.25° long. This glow is the light of 1,000 stars that are 4,600 lightyears away and extend across 18 lightyears. Charles Messier discovered it by chance in 1774, when a comet passed nearby. ☐ **SEEN IT**

3. 35 Cas

10x 50 If you imagine that Segin (Epsilon (ε)) and Ruchbah (Delta (δ)) and Gamma (γ) Cassiopeiae are the apexes of a rhombus, you'll see a triangle of 6th magnitude stars at the 4th apex. The one nearest to Segin is 35 Cassiopeiae. Its line-of-sight companion (mag. +8.4) is easy to see an arcminute to the north. The brighter of the pair is very white, but see if you can detect any colour in the companion. ☐ **SEEN IT**

4. The Queen's Kite

10x 50 Go back to Ruchbah and locate Chi (χ) Cassiopeiae 1.5° to the southeast. Continue another 0.75°, where you will find the mag. +7.3 star in the middle of a pentagon of stars of which Chi Cas is the brightest. The kite's 1.5°–long tail extends southward from the most easterly star of this pentagon. Note the varied colours of the stars: the two brighter 'wingtip' stars are yellow, while all the fainter ones are brilliant white. ☐ **SEEN IT**

5. Melotte 15

15x 70 Melotte 15 makes the third apex of an equilateral triangle with Segin and Iota (ι) Cas. You should be able to resolve eight or so stars from this bright, large (20 arcminute) glow. Even averted vision teases only a few more fainter stars into visibility. If you have good skies and a UHC filter to put over an eyepiece, see if you can detect the surrounding nebulosity (IC 1805) that gave birth to the cluster. ☐ **SEEN IT**

6. Pazmino's Cluster

10x 50 Identify CS Camelopardalis and pan 1.5° due west, where you will find an unremarkable little trapezium of 7th and 8th magnitude stars; this is Stock 23, or Pazmino's Cluster. With 50mm binoculars you can see that it's more than a trapezium and you may be able to resolve about half a dozen stars against an ethereal glow about 10 arcminutes in diameter. ☐ **SEEN IT**

☑ Tick the box when you've seen each one

PETE LAWRENCE X 3

THE SKY GUIDE CHALLENGE

Can you see one of our Solar System's outermost planets, Uranus, with the naked eye?

It's often stated that the planet Uranus is visible to the naked eye. However, if you ask someone whether they have actually seen it unaided, the answer you'll normally receive is no. The reason for this is that this distant planet shines at the edge of naked-eye visibility and any direct views of it aren't always conclusive.

Most of us live under less than perfect skies. An average dark sky will have a limiting magnitude – that's the faintest star you can see – somewhere between mag. +5.0 and mag. +5.5. Country locations may push this further, perhaps down to mag. +6.0 or even mag. +6.5 from really dark locations.

In addition, the limiting magnitude will vary with altitude on the sky. Although you might be able to see a mag. +6.0 star at the zenith directly overhead, at 10° altitude the story will be completely different. Fortunately, Uranus is currently the UK's best-placed planet, able to reach an altitude slightly over +50° when due south. This month it shines at mag. +5.7, tantalisingly close to the quoted typical naked-eye limit of +6.0 from a dark-sky site.

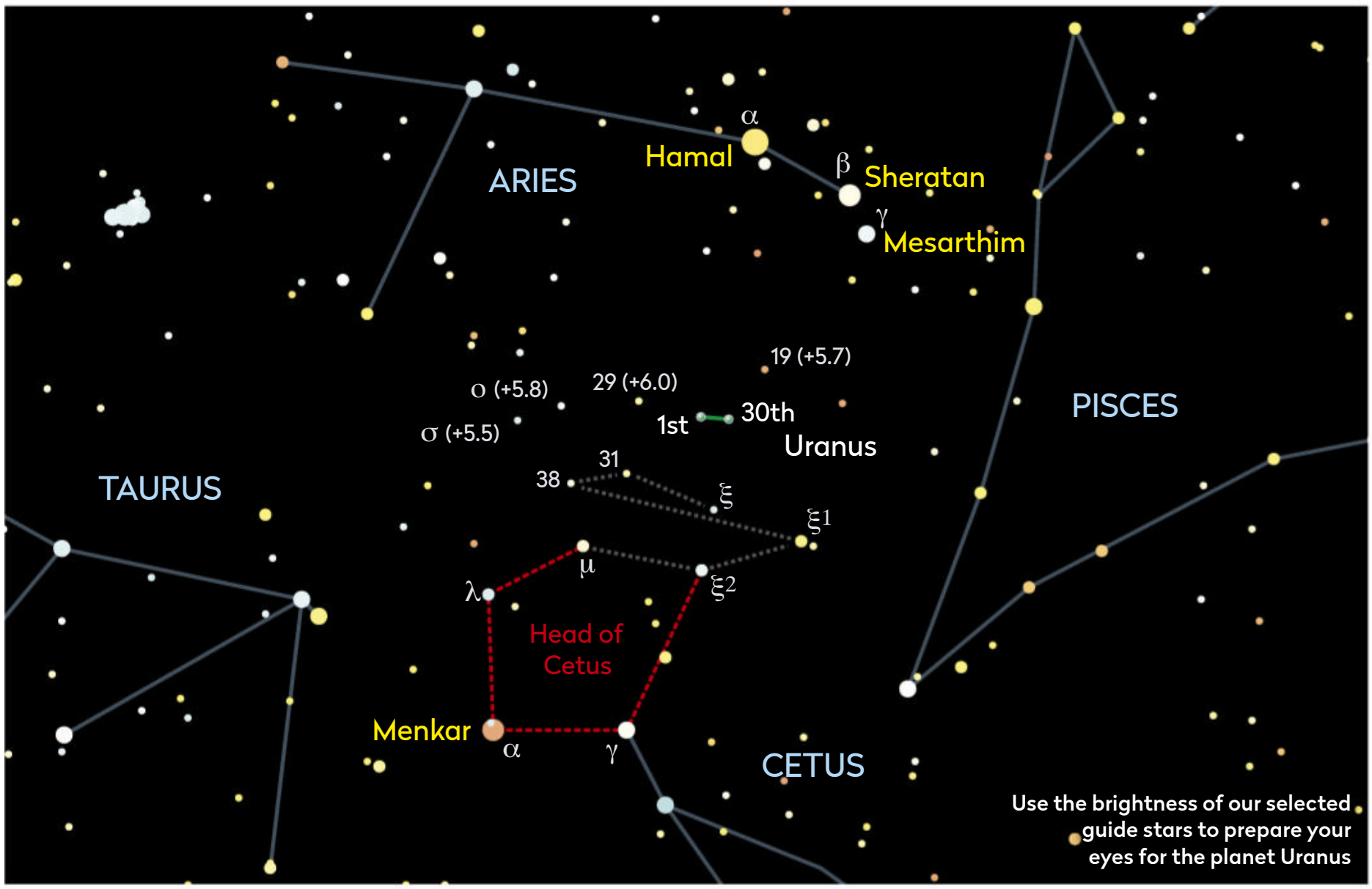
Fortunately, Uranus is currently the UK's best-placed planet

Another thing that is in the planet's favour is its location against the stars, placing it against a rather barren patch of sky. A few stars of similar magnitude are nearby, and these can be used productively to navigate towards the planet.

The first thing to do is prepare. Locate a dark spot where you will be able to avoid any contact with light sources for at least 40 minutes. Obviously, this also means timing your observation for a period when the Moon is out of the way. This month, the period between 9–22 November should be ideal. Allow yourself 20 minutes in total darkness to become dark adapted. Once this is achieved you can locate the three brighter stars in Aries, Hamal (Alpha (α)), Sheratan (Beta (β)) and Mesarthim (Gamma (γ) Arietis). Next, look for the pentagonal shape that represents the head of Cetus; its brightest star, Menkar (Alpha (α) Ceti), is the one you're after.

Uranus lies 60 per cent of the way along a line from Menkar towards Sheratan at the start of the month and then slips slightly southwest throughout November. Use our chart (below) to locate the useful guide stars that sit below the planet's position.

The selected guide stars are useful because they present a range of magnitudes, which allow you to 'approach' the brightness of Uranus. Start with Mu (μ) then Xi^2 (ξ^2) and Xi^1 (ξ^1) Ceti, all shining at mag. +4.3. Now go dimmer by moving on to 38 Arietis at mag. +5.2 , 31 Arietis at mag. +5.6, and finally mag. +5.7 Xi (ξ) Arietis before heading north to Uranus. Hopefully you can then add Uranus to the list of naked-eye planets you've seen.



DEEP-SKY TOUR

We explore the celestial highlights located around the western foot of Perseus

1 NGC 1499

This month we look at objects scattered around the pattern of stars depicting Perseus's western foot. Lodged in his shin is the emission nebula NGC 1499, also known as the California Nebula because it's outline resembles the US State. NGC 1499 has an integrated magnitude of +5.0, but as it's spread over a 145 x 40 arcminute area, its surface brightness is quite low, making it a challenge to see visually. It's located between Menkib (Xi (ξ)) and Zeta (ζ) Persei and has been seen in 7x50 binoculars. It best suits a low power view; hydrogen-beta filters can bring out the nebula, revealing it as a gentle glow elevated in brightness against the background sky. ☐ **SEEN IT**.

2 NGC 1342

Using the imaginary line between Epsilon (ε) and Xi Persei, identify the mid-point and head 5.3° to the west to locate the mag. +6.7 open cluster, NGC 1342. This is a rich but loose cluster; a small aperture shows a fair number of stars grouped together in an approximately rectangular area 12 x 7 arcminutes in size. The rectangular shape is echoed in the star patterns: three distinct star strings defining two shorter sides and one long side of the shape. A 250mm scope reveals about 60 stars in the cluster, the brightest of which approach mag. +8.5, while larger apertures or photographic setups will reveal a mix of oranges and blues in the cluster stars. NGC 1342 is around 400 million years old. ☐ **SEEN IT**.

3 IC 351

Next is planetary nebula IC 351, a 12th magnitude object, 8 x 6 arcseconds in size. Although visible in a 150mm scope, it appears virtually star-like at powers less than 100x. Navigate 1.9° east of NGC 1342 to locate HIP 17203. Now look 1.3° south-southeast to find HIP 17460. A line drawn from HIP 17203 through HIP 17460, extended for 1.5° (both stars are 1.3° apart) brings you close to IC 351. A 300mm scope shows a small stellar object at low powers, while increased magnification reveals a circular-looking disc with surface brightness. High power views show that the disc is not uniform in brightness, with a number of bright spots around its periphery. ☐ **SEEN IT**.

▲ **Our final target this month is IC 348, a wonderful stellar cluster with embedded nebulosity**

4 IC 2003

IC 2003 is another planetary nebula, this time located at the mid-point of the line joining Xi to Zeta Persei, which shines at mag. +11.5 and has apparent dimensions of 7 x 6 arcseconds. Small scopes tend to deliver a view that hardly differentiates the planetary from the surrounding stars; while a larger aperture will reveal its disc and show that unlike IC 351, this planetary nebula appears to show a brighter condensation at its centre. Its host star, located at nebula's centre, is faint at mag. +16.5. ☐ **SEEN IT**.

5 IC 1514

We cross into Taurus to round off a planetary nebulae hat-trick. IC 1514 is found by extending a line from Atik (Omicron (ω)) to Zeta Persei, 1.5x times again. IC 1514's central star is reasonably bright at mag. +9.4, while two slightly brighter stars flank the nebula, one of mag. +8.4, 8 arcminutes to the north, and one of mag. +8.1, 8.5 arcminutes to the south. This is a larger object than our two previous targets; it presents a 1 arcminute disc with a 150mm scope, increasing to 2 arcminutes with a 300mm. Larger apertures also show the nebula to have a 'texture' of irregular brightness. ☐ **SEEN IT**.

6 IC 348

Our final target is back in Perseus. IC 348 sits just to the south of Atik. It's best described as a cluster with embedded nebulosity, also known as reflection nebula VdB 19. The most prominent pattern is a right-angled triangle formed from mag. +8.5, +9.9 and +10.8 stars, with the longest side of the triangle being around 6 arcminutes. Most of the fainter cluster stars are seen around the two stars marking the triangle's eastern edge; a faint ring-like pattern may be seen. The nebula is tricky to see visually due to Atik's close proximity, but its brightest portion surrounds the northwest star in the triangle, HIP 17465, which has a mag. +9.7 companion next to it. ☐ **SEEN IT**.

MICHAEL DEGER/CCDGUIDE.COM, CHART BY PETE LAWRENCE

This Deep-Sky Tour has been automated
ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.

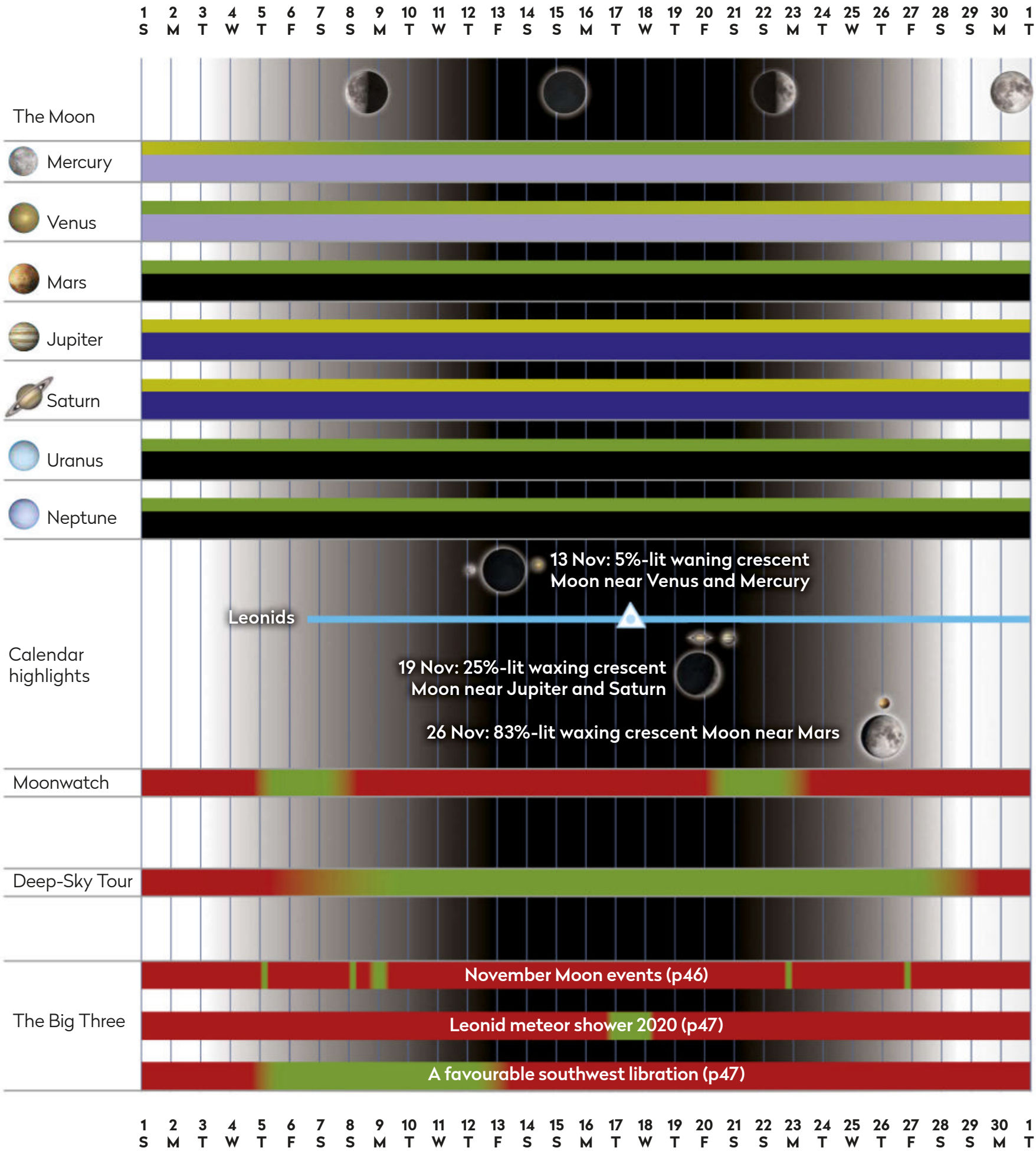
More **ONLINE**

Print out this chart and take an automated Go-To tour. See page 5 for instructions.

04h30m
+35°
04h00m
+40°
+40°
03h30m
54
ε
1
NGC 1499
ζ
Menkib
2°
1°
N
W
S
IC 2003
4
3
IC 351
NGC 1342
2
5
NGC 1514
+30°
42
40
ζ
o
Atik
IC 348
6
ψ
PERSEUS
TAURUS
04h00m
+30°
03h30m
+35°

AT A GLANCE

How the Sky Guide events will appear in November



KEY

Observability
Optimal | Poor

Best viewed
Morning twilight | Daytime | Evening twilight | Night

Sky brightness during lunar phases
Dark (first quarter) | Light (full Moon) | Dark (last quarter) | Total darkness (new Moon)

IC Inferior conjunction (Mercury & Venus only)
SC Superior conjunction
OP Planet at opposition
Meteor radiant peak
Planets in conjunction

Full Moon
First quarter
Last quarter
New Moon

CHART BY PETE LAWRENCE

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#astrophoto2020

Self-portrait under the Milky Way © Evan McKay

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BBC Sky at Night MAGAZINE

20 YEARS OF THE ISS

This month marks two decades of human occupation on the International Space Station. **Nisha Beerjeraz-Hoyle** looks at the ISS's history and how it's preparing a new generation of space explorers

NASA/ROSCOSMOS

Frontier in space: capable of running until 2028, the International Space Station (ISS) is the largest structure ever built in space

Astronaut Steve Bowen working on the ISS's solar arrays in 2008. As of going to press, there have been 231 spacewalks to construct, upgrade and maintain the orbital outpost

▲ First visitors: the crew of Expedition-1 on the ISS in 2000: (from left) William Shepherd, Yuri Gidzenko and Sergei Krikalev

With each sunrise we awake and go about our daily lives with little thought that 400km above Earth, a group of humans are living in an orbiting laboratory. Travelling at 27,600km per hour, they see 16 sunrises a day and make one orbit around our planet in just 90 minutes. There are generations growing up today who have only known a time when the human race lived both on and off planet Earth.

For the past 20 years there has been a continuous human presence in space on the International Space Station (ISS). It began two decades ago this month when, on 2 November 2000, the crew of Expedition-1 – US astronaut William 'Bill' Shepherd, and Russian cosmonauts Sergei Krikalev and Yuri Gidzenko – docked their Soyuz spacecraft with the ISS, climbed through the hatch and switched on the lights. Since their arrival, a steady crew rotation means the ISS has never once gone unoccupied.

The ISS is an engineering marvel: the largest structure ever built in space. It weighs around 420,000kg (more than 320 cars) and at 109m is longer than a football pitch. Modular in design and constructed over 13 years, it has eight solar arrays, a main truss 'backbone' and pressurised habitation modules. The living quarters are altogether larger than a six-bedroom house and include six sleeping quarters, two bathrooms, a gym and a 360° view bay window called the Cupola.

"When you look at the whole assembly, there were around 37 Space Shuttle flights," says NASA astronaut Jeff Williams, who saw four trips to the ISS, including STS-101, the third mission devoted to its construction. "And there were also about roughly 40 Russian rocket launches that supported the assembly of the ISS. Most of those flights took up a major component; some were logistics missions that supplied the ISS."

Getting ready

Back in 2000 the ISS was a fraction of its current size with just three modules providing the basics for permanent habitation. Zarya was the first module launched into orbit in 1998 (funded by the US, and built and launched by the Russian space agency Roscosmos), shortly followed by the US-built and launched Unity module. After an 18-month delay, the Russian-built Zvezda, which would provide life support systems for the ISS, was connected to Zarya in September 2000, in readiness for the first crew.

Williams explains: "It was not an easy road even to get to that point: not only the political support but the technical integration of all of these components that

NASA/ROSCOSMOS, NASA X 3, SCOTT KELLY/TWITTER X 3

▲ Going ape: ISS astronaut Tim Peake gets chased during a prank

Stranger things

The ISS has played host to some oddities... astronauts are only human, after all

A gorilla Ok, there isn't really a gorilla on the ISS, but there is a gorilla suit sent up in 2016 by astronaut Mark Kelly, as a birthday present for his twin brother Scott. He used it to prank Tim Peake (above).

Pizza Hut In 2001, Pizza Hut sent specially made pies to the ISS, after cosmonaut Yuri Usachov mentioned he had a craving.

Bagpipes... In 2015, astronaut Kjell Lindgren played 'Amazing Grace' on a set of bagpipes in tribute to a colleague who had passed away.

...And other musical instruments Over the years there has been quite an ensemble, including a guitar, flute, piccolo, keyboard, alto saxophone, koto and a didgeridoo.

An espresso machine In 2015, astronauts got a chance to brew a real cup of coffee from an espresso machine dubbed the 'ISSpresso', designed by Italian companies Lavazza and Argotec.

Christmas decorations The crew have a box of festive decorations, including a miniature Christmas tree, stockings and Santa hats.

Tremor, Earthy, Miss Mouse and Buzz These are soft toys that have earned their space wings. Tremor, a sequined dinosaur, arrived earlier this year aboard SpaceX's Dragon.

ISS IN NUMBERS

27,600
Orbital speed in kilometres per hour

420
Weight in tonnes

4 billion
Maintenance cost in US dollars per year

240
Number of individuals who have visited

16
Frequency of Earth orbits in 24 hours

109
Length in metres, end-to-end

4
Minimum time in hours for a spacecraft to arrive after launch

2,700
Individual science investigations

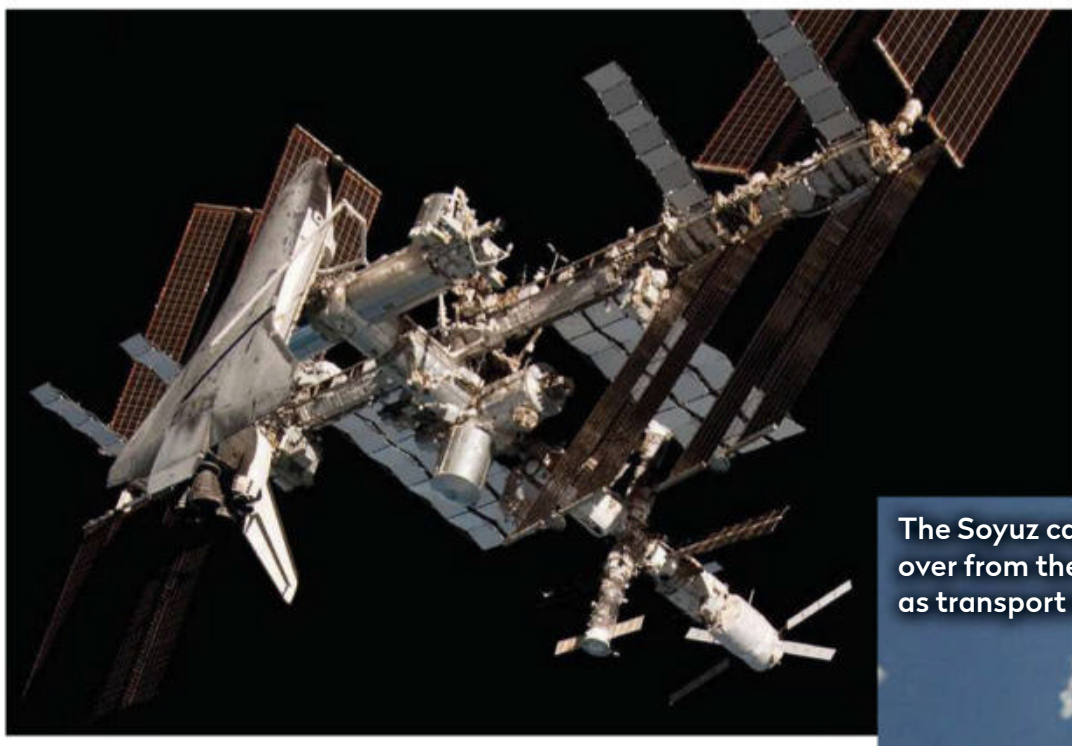
350,000
Number of sensors monitoring crew health and safety

1,500,000
Lines of flight computer code

388
Cubic metres of habitable space

73
Wingspan in metres of the solar arrays

231
Spacewalks since launch, including during construction



▲ A docked Space Shuttle was a familiar sight on the ISS until the 2003 Columbia disaster put Shuttle flights on hold


The Soyuz capsule took over from the Shuttle as transport to the ISS

needed to go together." By 1993, nine years had passed since US President Reagan's missive to build a space station within the decade. Space Station Freedom, as it was then called, had undergone several redesigns as NASA engineers struggled with the challenges of building a large, stable structure in space.

But the fall of the Soviet Union made way for former adversaries to forge new partnerships, and Roscosmos brought invaluable experience from its own space stations, Salyut and Mir. Together with the Canadian Space Agency, ESA and Japan's JAXA, collaboration between 15 nations saw a truly International Space Station emerge.

Pulling together

The strength of this partnership was demonstrated when the 2003 Space Shuttle Columbia tragedy cost the lives of all seven astronauts on board and halted further flights of the Shuttle. Williams lost close friends that day. "It's a great testimony to the strength of the partnership, particularly between the US and Russia... just to keep the ISS going while we addressed the issues that caused the Columbia tragedy, which of course grounded the Space Shuttle for between 2-3 years." This led to the now familiar sight of the Russian Soyuz capsule transporting Russian, US and European astronauts to the ISS.

The ISS is not just a beautiful space habitat, but primarily a unique science laboratory, allowing for experiments that aren't possible on Earth. These range from studying how both the human body and plants react to life in space, to understanding how materials behave in microgravity. The science ▸

Assembled in orbit: a ship built in space

Construction of the ISS took 10 years and unprecedented international collaboration

1 Starboard Solar Arrays
2 S6 Truss
3 S5 Truss
4 Solar Arrays
5 S3/S4 Truss
6 ExPRESS Logistics Carrier (ELC) 2
7 External Stowage Platform (ESP) 3
8 ELC 4
9 S1 Truss
10 AMS Experiment
11 Zvezda Service Module
12 Docking Compartment (DC 1)
13 Poisk Research Module
14 Zarya Control Module
15 Rassvet Research Module
16 Pressurised Mating Adaptor (PMA 1)
17 Canadarm2
18 S0 Truss
19 Quest Airlock
20 Z1 Truss
21 ESP 2
22 Unity (Node 1)
23 Bigelow Expandable Activity
24 Thermal Control Radiators
25 Solar Arrays
26 P1 Truss
27 ELC 3
28 ELC 1
29 P3/P4 Truss
30 P5 Truss
31 Port Solar Arrays
32 P6 Truss
33 Destiny Laboratory
34 Tranquility (Node 3)
35 Permanent Multi-Purpose Module
36 Cupola
37 ESP 1
38 PMA 3
39 Japanese Logistics Module
40 Japanse Exposed Facility
41 Kibo (Japanese Experiment Module)
42 PMA 2
43 Harmony (Node 2)
44 Columbus Laboratory

ILLUSTRATION BY PAUL WOOTTON, NASA X 3, NASA/SAMANTHA CRISTOFORETTI/TWITTER

▸ is not all geared towards future spaceflight either. Recent experiments include growing protein crystals to investigate the causes of Parkinson's disease and cancer, while using new sensor technologies to monitor astronauts' core temperatures in space can help detect early signs of heat exhaustion for occupations such as firefighting.

Astronauts have a canny way of making their experiments fun too. In 2015 Italian astronaut Samantha Cristoforetti posted a selfie of herself drinking the first espresso in space out of a zero-g cup. Experiments like these allow scientists and engineers to understand how fluids behave, not just to give astronauts a decent cup of coffee (although, as many of us would agree, this would be totally understandable) but to make space habitats safer.

A working day for astronauts does not just entail interesting science experiments or even spacewalks: they are caretakers of the ISS, trained to repair and install parts, contributing to the space station's longevity. They are their own minor-injury medics, cleaners, photographers and even hairdressers, and must exercise for at least two hours everyday to prevent bone and muscle deterioration.

Time out

In their spare pockets of time ISS astronauts indulge our curiosities, showing us how they use the toilet, or how they sleep and eat, and even how to play a prank in space – the answer, if you're US astronaut Scott Kelly, is to don a gorilla suit, jump out of a cargo box and chase a terrified Tim Peake through the ISS (see box on page 63). Those who use social media have captivated us with breathtaking views of Earth photographed from the famous Cupola – "the window on the world", as Williams describes it, himself an avid photographer and part of the crew who installed it on the ISS in 2010.

"The variety of what you can see is endless in terms of studying Earth. I had two motivations to capture the experience: one was to be able to recall it myself but the bigger motivation was to vicariously bring

Nisha Beerjeraz-Hoyle is a science journalist and space writer

A window on the world: astronaut Tracy Caldwell Dyson looks out from the ISS's Cupola observatory in 2010

▲ Taking a break: Samantha Cristoforetti (above, left) enjoys the first espresso in space on the ISS in 2015; Paolo Nespoli (above, right) settles down in his sleeping bag in 2007

► Clean and press: Dan Burbank exercises on the ISS in 2011 using the Advanced Resistive Exercise Device (ARED), a machine designed to deliver a full-body workout

that unique experience to people back home on Earth."

As the ISS residents gaze down on us, we have looked back up at them traversing the sky 350km overhead. The ISS has been our metaphorical North Star, reminding us that the future of space exploration is here now. Now that future, and the fate of the ISS, is at a critical turning point.

With lofty goals of a Moonshot by 2024, NASA has been working to establish a low-Earth orbit economy, with the ISS as a commercial hub. Private enterprise on the ISS isn't new – Adidas used ISS astronauts to test its 'Boost' trainers in microgravity, while private companies have supplied modules, such as Boeing's inflatable airlock, BEAM.

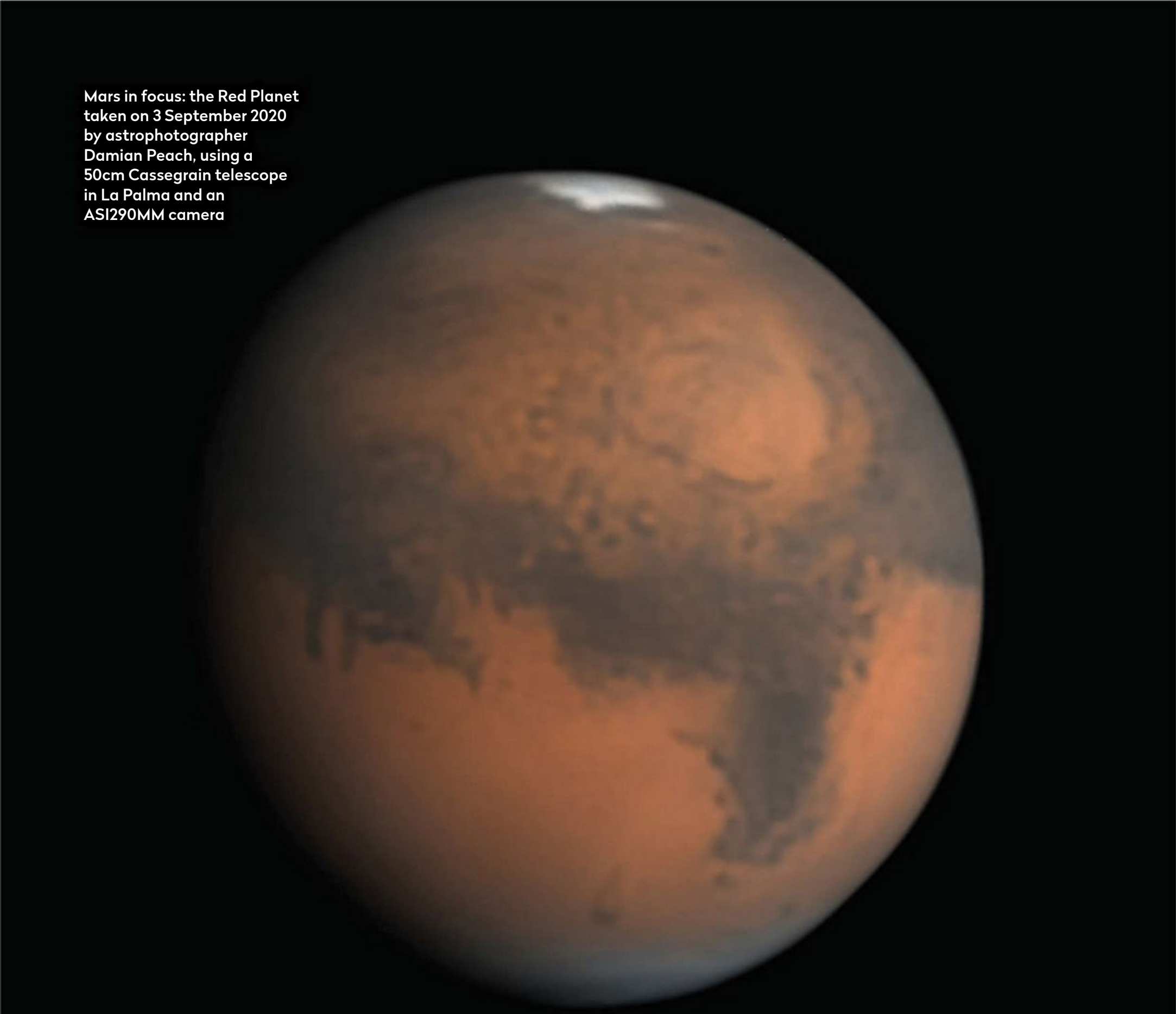
More than just providing an innovation lab for big brands though, there are now wider plans for privatising ISS operations, at least in part, to meet the £3–4 billion a year maintenance costs – that's around half of NASA's yearly spaceflight budget.

If a new shared-ownership model can't be established, then the ISS may become an abandoned ship, a spare parts factory for other space stations, or purposely deorbited to burn up in the atmosphere. Williams says all options are still up for grabs: "All of these things are important to look at and to try and develop, and some will probably come to fruition." However, he also expressed a firm belief that maintaining an orbital presence, "will be necessary to develop an infrastructure at and around the Moon."

Future prospects

Capable of running until at least 2028, there is still plenty of opportunity to spot the ISS and marvel that in the hostile environment of space, we have become permanent citizens. While attention turns to the Moon and Mars, it's worth remembering that were it not for the ISS, we could not even consider going further into the Solar System. As discussions around a new era for the ISS continue, there could be no better time to celebrate the past 20 years, which have founded the beginning of a new frontier for humans in space.

► **Turn to page 98 to read about astronaut Samantha Cristoforetti's experiences on the ISS**

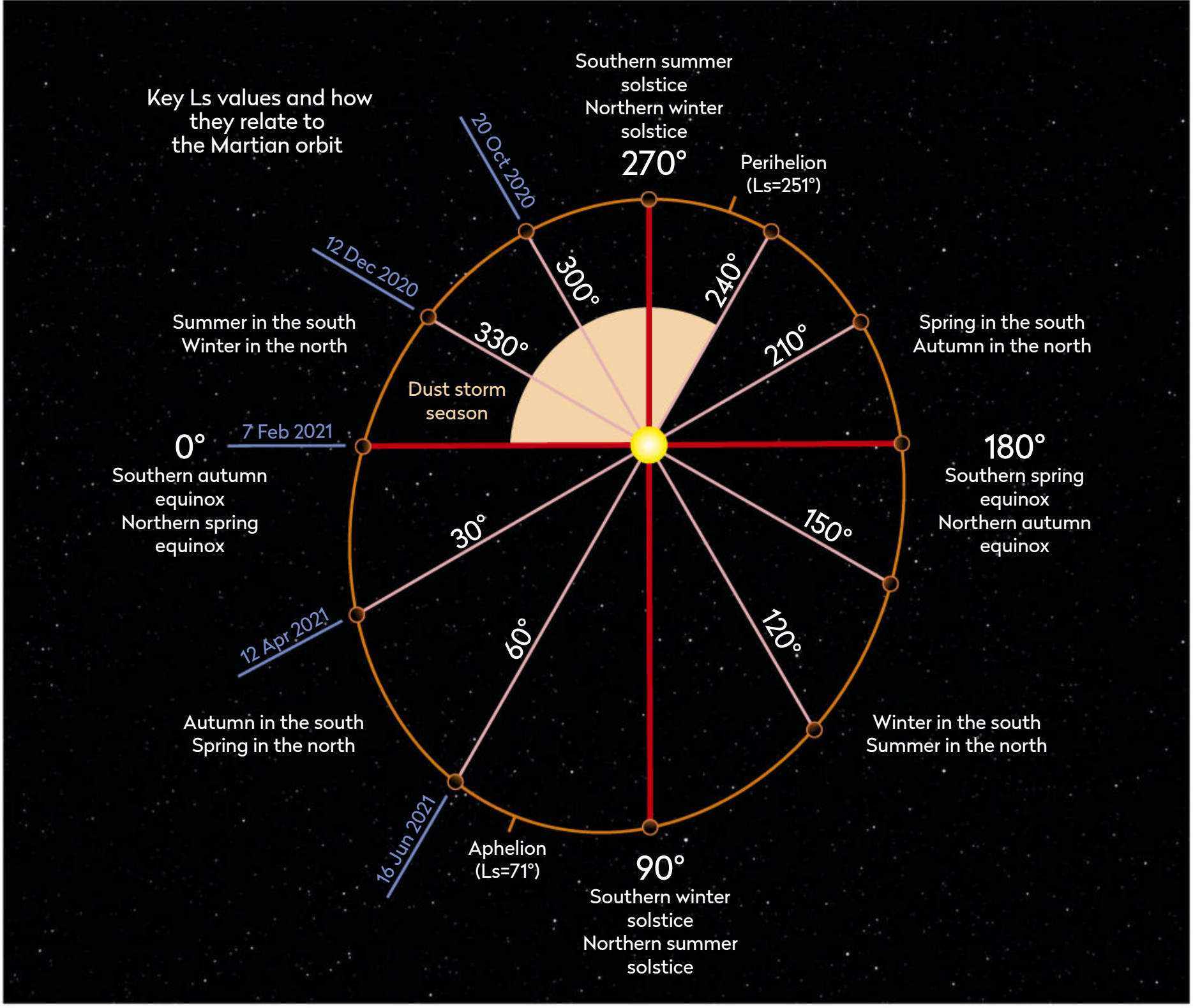


Mars in focus: the Red Planet taken on 3 September 2020 by astrophotographer Damian Peach, using a 50cm Cassegrain telescope in La Palma and an ASI290MM camera

The Red Planet

An ember glowing bright

Mars is now past opposition, but as **Paul G Abel** explains, the planet will remain with us in evening skies for many more months of useful observations



▲ **The Martian seasons: the values of solar longitude (Ls) as Mars goes around the Sun – with equivalent Earth dates in blue**

This October, the planet Mars came to opposition and was the best it has been in UK skies for many years. Looking like a brilliant glowing coal, it was quite unmistakable high up in the dark evening skies. As planet Earth is now moving away from Mars, it continues to get smaller and fainter, and you might think that there is little left to explore. However, nothing could be further from the truth – it will remain high and bright in the evening skies for months to come; for many its appearance at a more convenient time in dark evening skies will be the time when it really grabs the attention.

"Mars is a dynamic world, and over the next few months there will be some fascinating changes occurring on the Red Planet"

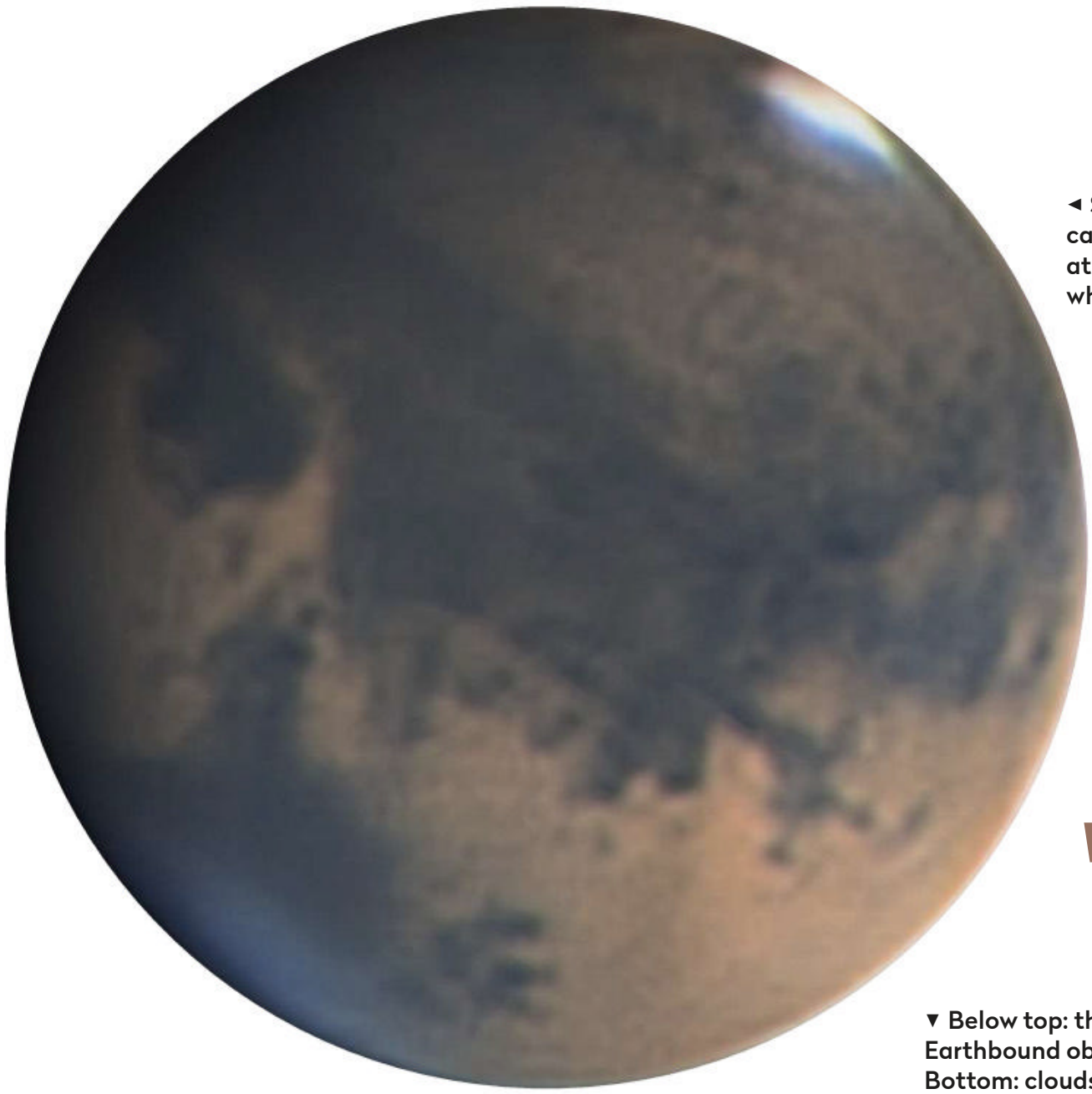
Mars is a dynamic world, and over the next few months there will be some fascinating changes occurring on the Red Planet. By the end of the year Mars will have an apparent diameter of 11 arcseconds – still big enough to be noticeable to naked-eye and binocular observers. Users of small to medium telescopes will find that the Red Planet's respectable diameter will be more than enough to follow the seasonal changes that are coming up, while owners of large telescopes will be able to follow for considerably longer as Mars remains above 6 arcseconds in diameter until the end of March 2021. Here we'll highlight some of the seasonal changes you can expect to see with a telescope, and how best to go about observing them.

A Martian year

Mars has an axial tilt of some 25° and so it experiences well-defined seasons of winter, spring, summer and autumn as it moves in its orbit around the Sun. Just like Earth, opposite hemispheres experience opposite seasons: summer in the northern hemisphere means winter in the south. Since many of the changes on Mars are due to the changes in seasons, it is important that we keep track of exactly where we are in the Martian calendar at any particular time. Astronomers have devised a simple way of doing that – it's called solar longitude, or Ls for short.

In the diagram above you can see that the Martian orbit is divided up into 12 intervals; Ls can be thought of as the angle made by Mars as it moves around the Sun. Astronomers take the autumn equinox in the southern hemisphere to be the value Ls=0° and our ►

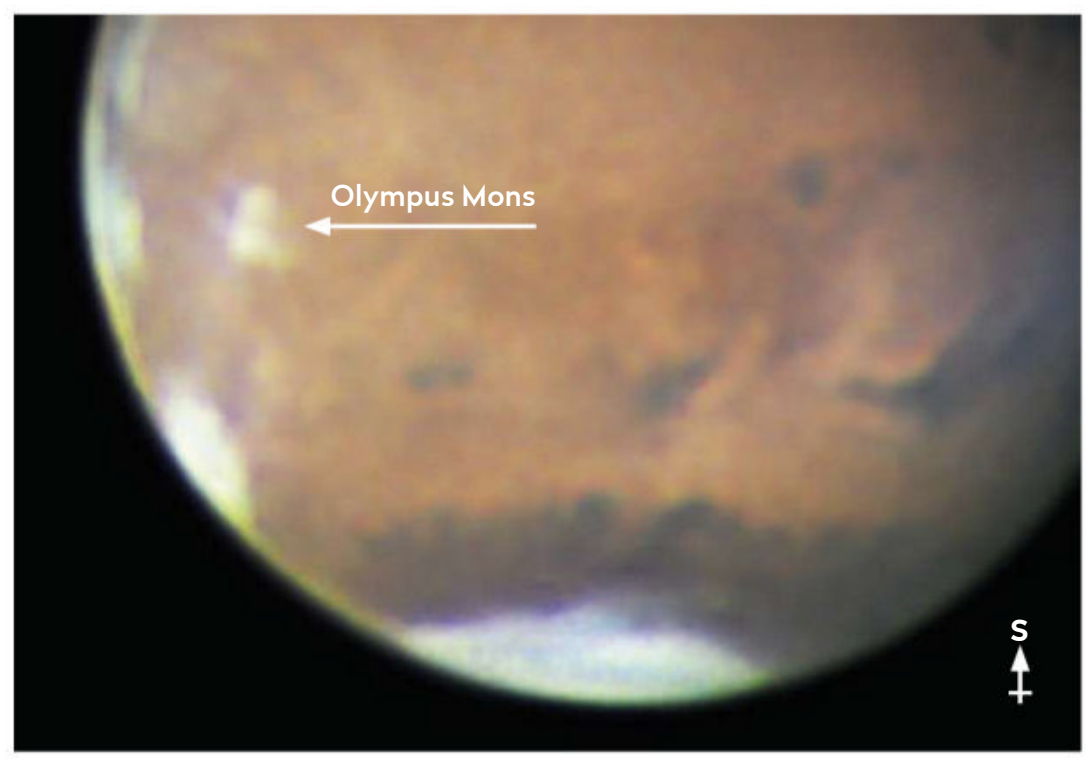
E. ENZMANN/DAMIAN PEACH, CHART BY PETE LAWRENCE

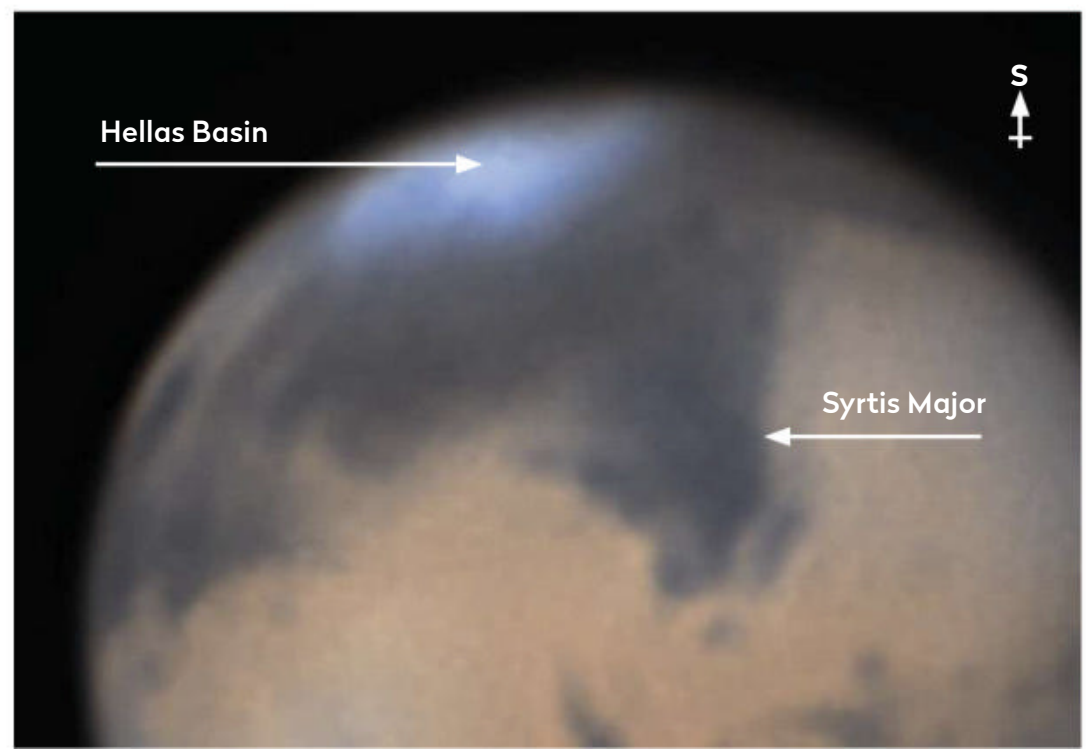


◄ Summer in the Martian southern hemisphere causes the southern polar cap (the white area at the top of this south-up view) to shrink, while large clouds form in the atmosphere

"Watch out for brilliant white clouds that collect around the Tharsis volcanoes"

▼ Below top: the location of Olympus Mons is revealed to Earthbound observers by the clouds around its summit Bottom: clouds are also known to gather in the huge Hellas Basin to the south of the triangular Syrtis Major





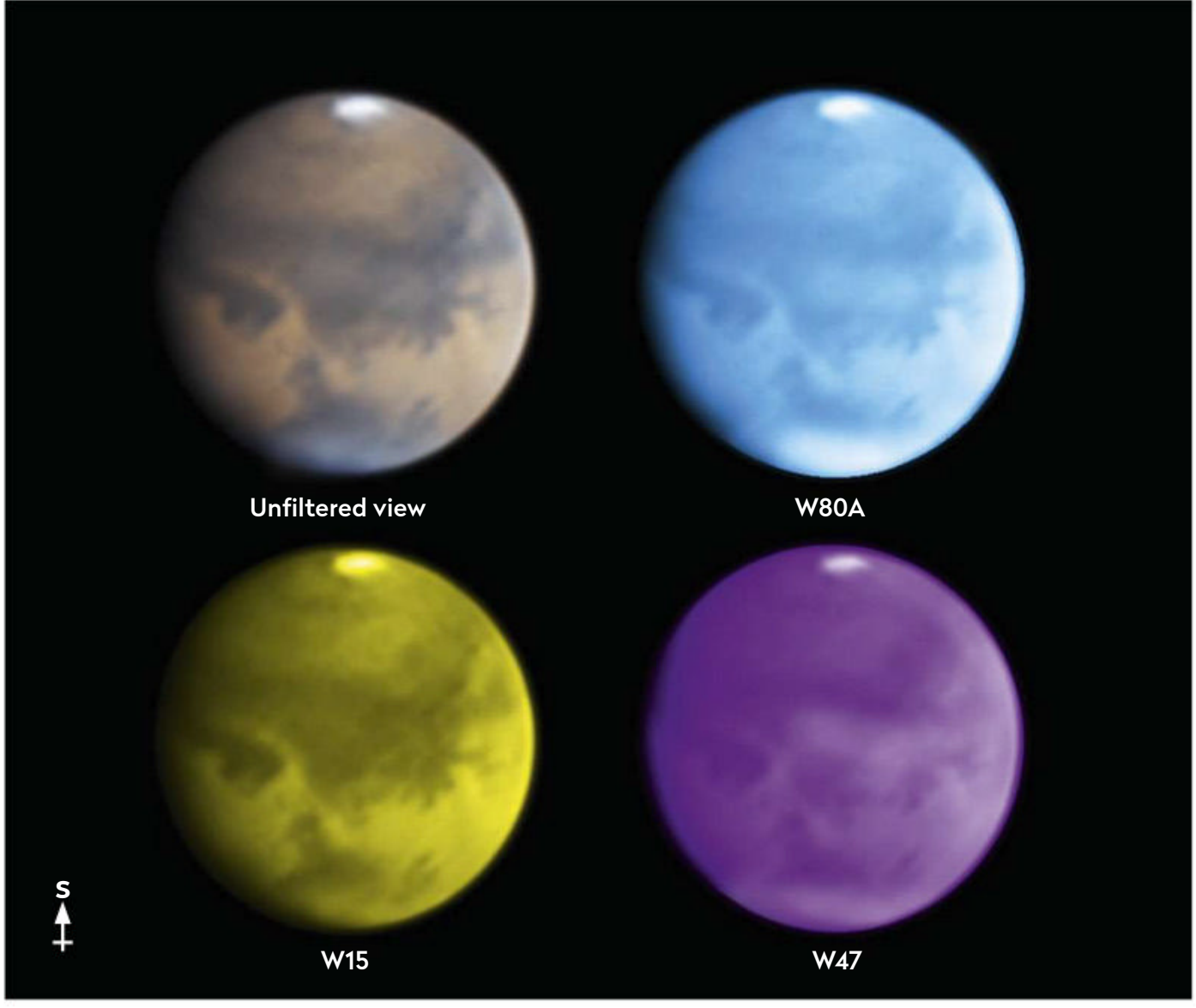
► first Martian month sees the value of Ls go from 0° to 30°, while the second month sees the Ls range go from 30° to 60° and corresponds to later summer in the south, meanwhile the northern hemisphere has passed into spring. We continue in this way until we have broken the Martian year up into 12 months, each spanning 30° of the Red Planet's orbit.

Of course, Martian months are longer than Earth's, since a Martian year is about twice that of our own. By looking up the value of Ls, we can tell exactly where Mars is in its orbit and work out what the seasons should be in either the northern or southern hemisphere. We can also mark out other important events: perihelion (when Mars is closest to the Sun) occurs at Ls=251°. So, when opposition occurs close to this value of Ls, we know it will be a 'perihelic' opposition – as was the case in October. You can find the value of Ls by using the free software WINJUPOS (which can be downloaded at **http://jupos.org/gh/download.htm**); it's the value called 'longitude of the Sun' in the 'Ephemerides' tab. *The Handbook of the British Astronomical Association* also gives the values in its 'Mars Section'.

Seasonal changes

At the start of November, Ls has a value of around 310° and so it's late summer in the southern hemisphere. A number of changes have started to occur – the southern polar cap (SPC) has now shrunk and this has returned volatiles, such as dust and water vapour, back into the Martian atmosphere. Watch out for brilliant white clouds that collect around the Tharsis

PETE LAWRENCE X 4, PAUL ABEL X 2



◄ Colourful views: Wratten filters make Martian dust clouds easier to see than in an unfiltered view (top left). Use light blue (W80A), yellow (W15) or violet (W47) filters to enhance cloud definition

volcanoes. Olympus Mons in particular can attract bright clouds; these indicate its position in small to medium telescopes – the Solar System's largest volcano is otherwise invisible to such apertures.

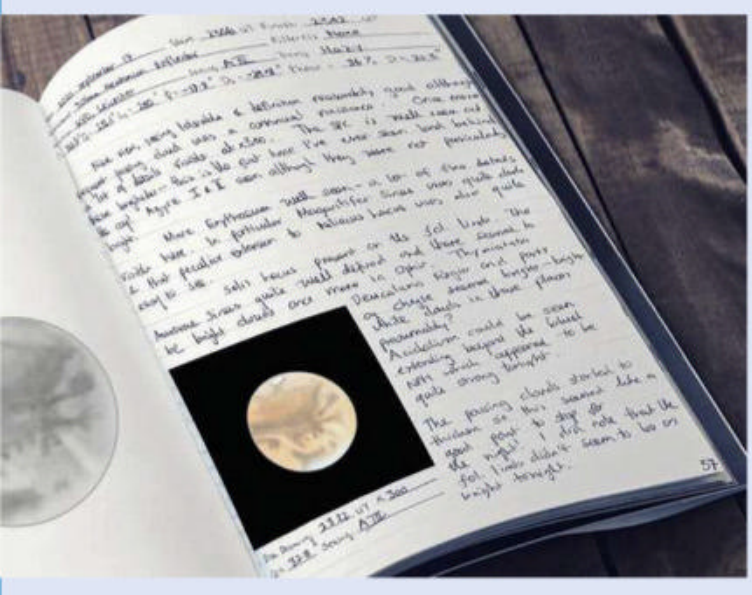
Bright clouds and fogs also collect in the deep basins; in January keep an eye on the Hellas Basin, to the south of Syrtis Major. It is not uncommon for Hellas to become filled with white clouds when it's near the morning or evening limb and as a result, it can become very bright. Eridania, Electris and Chryse are regions also prone to attracting clouds.

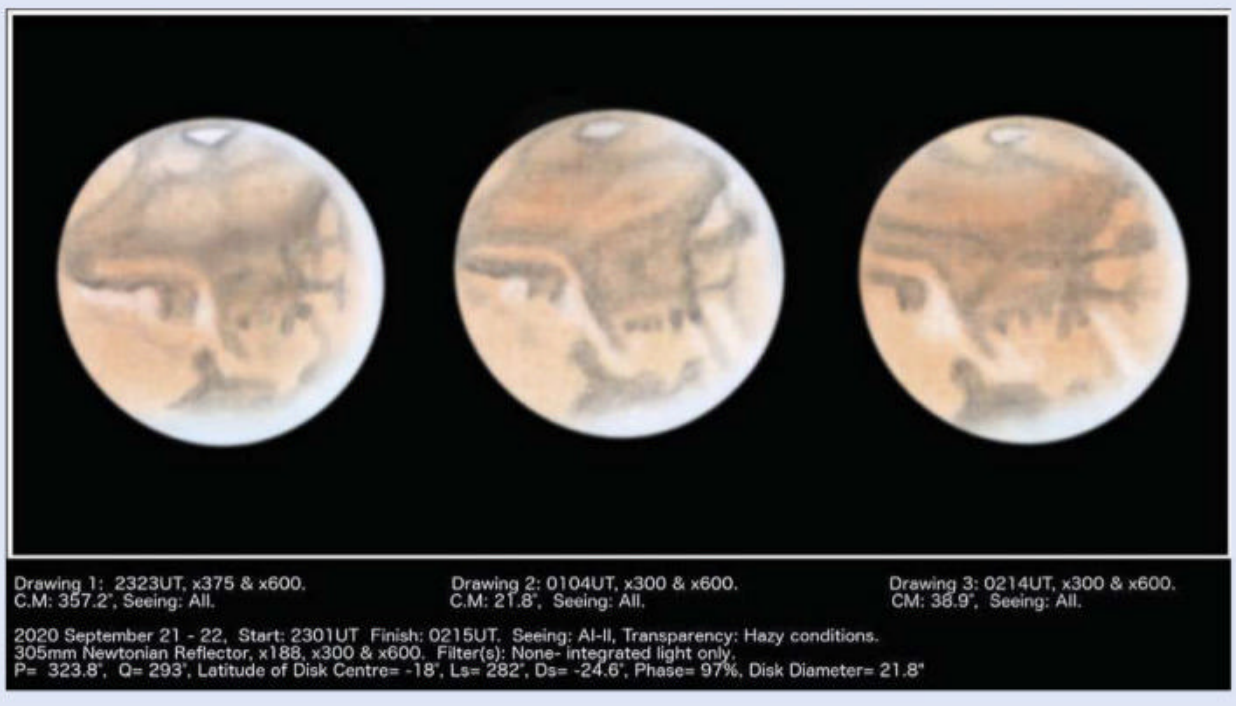
Filter familiarity

Visual filters are a great help when observing Mars – most telescopes come with a set and they are very easy to use. You simply screw them into the thread at the base of your eyepiece. Each filter is unique, and you can identify each one by looking at the W number on the side; this gives the filter's 'Wratten number'. If you have a small to medium sized telescope, try using a light blue filter (W80 or W80A) to increase the definition of white clouds. ►

Keeping a Mars log book

Record your observations, they could be useful for scientists in the future





▲ Drawings from the author's log book, done from 21–22 September 2020, show observations of Mars with a 12-inch Newtonian telescope. They show the rotation of Mars and the dispersion of various fogs and mists in the valleys

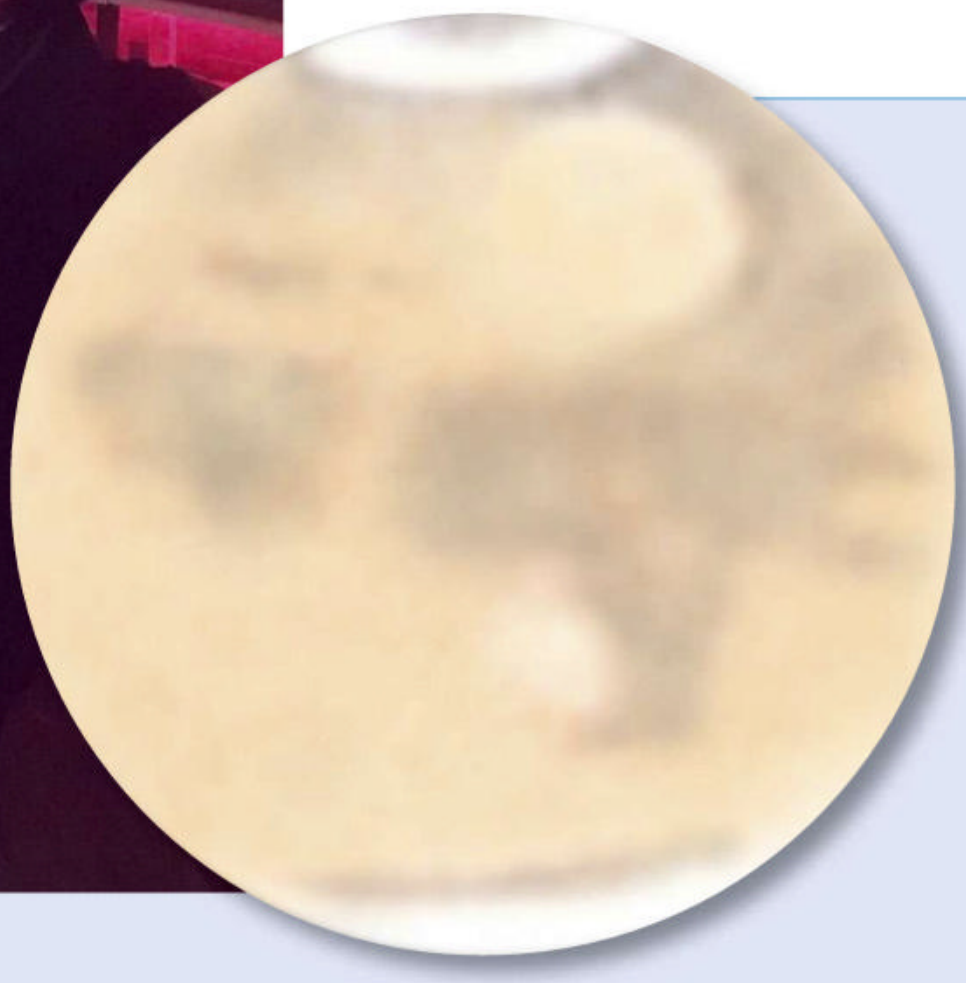
Your log book is a great way of keeping track of all the seasonal changes you've observed on Mars. It should be a bound notebook, and for each observation you need to record the date, the time (in UT), the telescope and magnifications used, alongside any drawings you make of Mars.

The process of making a Mars drawing is straightforward. To begin, make a 'Mars blank' – this is a circle, 50mm in diameter, drawn on a sheet of paper you can take out to the telescope to start your drawing.

At the telescope, first spend some time looking at Mars to see what features are present. Then, when you are ready, use a 3B pencil to draw in the terminator on your 'Mars blank' along with the main dark features. Next, draw in the finer features that may be present – like the southern polar cap, or bright clouds – and note down the time and magnification used.

Make sure you don't take longer than 15 minutes to make a drawing: Mars's rotation will have moved the features from where you've originally placed them.

Close-up view: the author uses the 24-inch Clark Refractor at Arizona's Lowell Observatory to observe Mars...



▲ ...and make a south-up sketch of the Red Planet's features while it was undergoing a dramatic dust storm

Catching dust storms

Fierce winds can whip Mars's fine dry soil into large clouds

Although the Martian atmosphere is tenuous, it is quite capable of producing powerful dust storms. Winds of half the speed of sound have been recorded. Typically, the dust storm season starts at about Ls =240° and it continues to Ls=0°. This means that we can expect to see them from now until early February.

The Martian dust storm season has been studied in great detail, and there are three types of dust storm which occur:

Local: these dust storms are confined to very small regions like a corner of the Hellas Basin.

Regional: these dust storms may cover an entire region like Syrtis Major, or indeed a whole hemisphere.

Global: the largest, these dust storms cover the entire planet. During this time the entire globe can become featureless even to large telescopes.

Local and regional dust storms tend to be the most frequent. During the previous opposition in 2018, I was able to observe a regional dust storm at the Lowell Observatory, in Flagstaff, Arizona (see picture, above).

Truly global dust storms are quite rare – two prominent ones occurred in 1975 and 1977, around the time that the Viking missions were approaching Mars.

There are a number of sites on Mars that are well known for producing storms, including the Hellas Basin, Solis Lacus, Noachis and Chryse, and you should survey these regions whenever you can. Storms always start off as bright yellow or orange clouds. Local ones will require a 150mm telescope or larger to be seen, but regional ones can be visible in smaller instruments. You'll find a red (W25), orange (W21) or yellow (W15) filter will also help enhance dust clouds and make them easier to see.

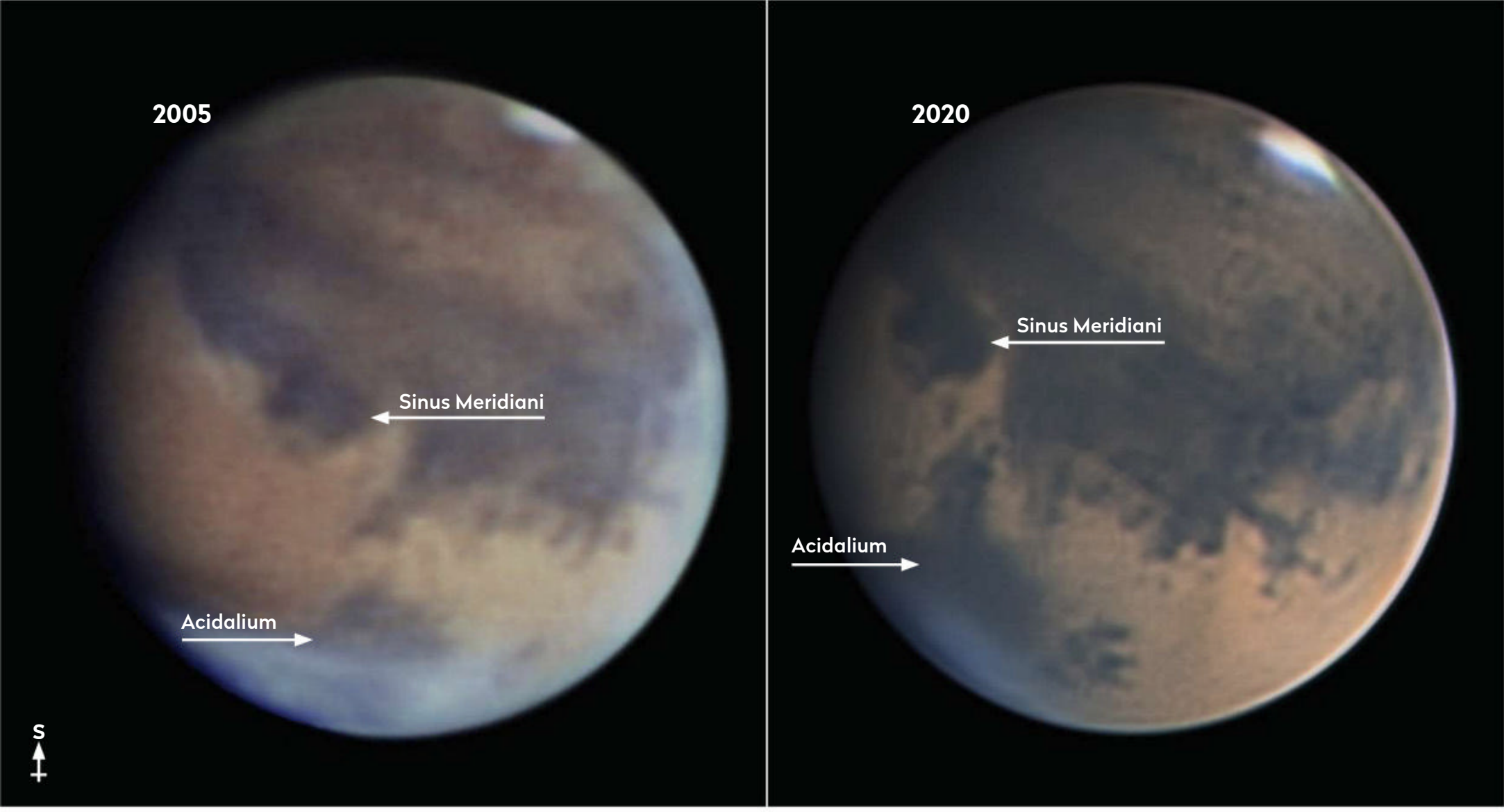
If a large storm does erupt, it is a good idea to record its progress; you can do this by sketching the region and plotting the size and location of the dust storm as it changes over time.

▸ If you do see fogs and white clouds, it is worth spending some time observing them as they can be quite dynamic, often forming and evaporating over the course of an hour or two. It is particularly satisfying to watch bright clouds which have collected in the early morning chill of the Hellas Basin, slowly disperse during the course of an observing session.

When bright clouds occur on the limb of the planet, they can be really quite brilliant. If you have a larger telescope, a W47 violet filter will help bring fine details out further. A W15 yellow filter will make the southern polar cap slightly easier to see, as it is now quite small and a challenge in small telescopes.

By January it is spring in the northern hemisphere and the vast north polar hood is extending quite a way south. You should be able to glimpse it as a bluish-white haze on the northern limb, and it will become more prominent towards the year's end. Mars's tilt will also start to change – from January onwards, the northern hemisphere will gradually be better placed for views of well-known albedo features like Acidalium and Elysium. By March, observers using larger scopes might be able to catch sight of the northern polar cap.

PAUL ABEL X 2, PETE LAWRENCE X 2



▲ Two views showing changes in Acidalium over 15 years; the shape of the dark albedo feature has been altered by dust-storm activity

"Dust storms can produce quite pronounced changes to the dark albedo features, as vast amounts of dust tend to be moved and deposited into new locations"

▲ A wispy band of cloud encircles Mars, visible north of Sinus Gomer (left) and extending over southern Syrtis Major (right)

At Ls=0°, a phenomenon known as the 'equatorial cloud band' (ECB) should start to make an appearance. The ECB takes the form of a thin white cloud along the equator; when it passes over darker regions like Syrtis Major, it can make the features appear bluish. Watch out for this from early February onwards.

The well-known dust storm season stars from about Ls=240°, so keep an eye out for them (see box on opposite page). These storms usually begin life as small orange clouds and they are easier to see if you use a red filter (W25) when observing Mars. Dust storms can evolve quite rapidly and it is important to track them and any surface changes.

Long-term changes

All of these seasonal effects result in long-term changes to the planet's surface. Dust storms in particular can produce quite pronounced changes to the dark albedo features, as vast amounts of dust tend to be moved and deposited into new locations. One only has to look back at a map of Mars drawn in the 1960s to see how a number of features like Syrtis Major and Solis Lacus have changed over time. In the last few years the northern hemisphere albedo feature known as Acidalium has changed considerably and it will be important to track any new changes which result in future dust storms.

It is well worth recording your observations in a log book (see box, page 69) as this will allow you to keep track of all of the changes and seasonal weather patterns that you have observed. It's also a great way to become familiar with Martian geography, especially if you have several drawings of the same feature.

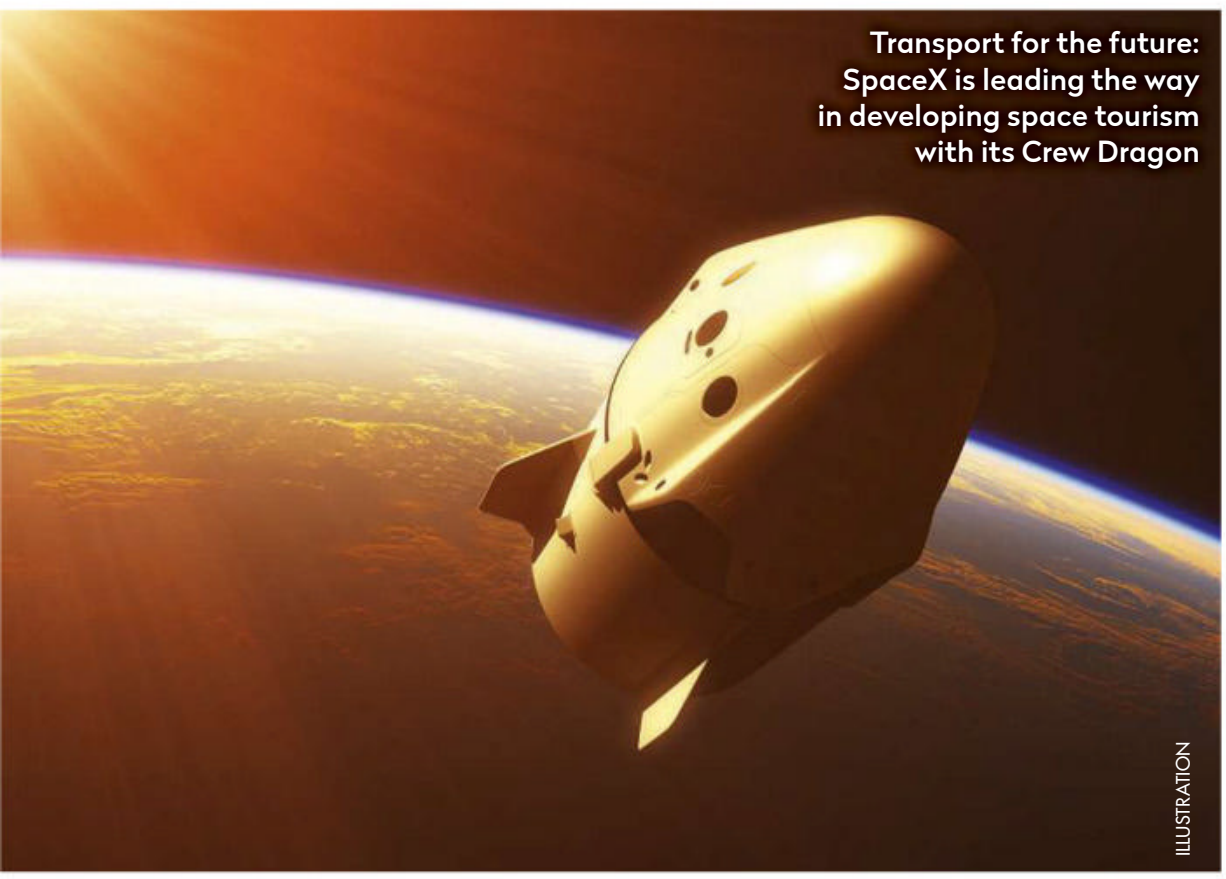
It is going to be some time before we have another splendid Mars apparition like the one we have at the moment. Take the chance to follow the Red Planet for as long as possible and keep track of all of the interesting developments occurring on it.

Paul G Abel is director of the British Astronomical Society's Mercury and Venus section. He is a theoretical physicist at the University of Leicester

EXPLAINER

Want to get to space? Here's how...

Ordinary people can leave Earth's atmosphere today, but are the prices sky high?



Transport for the future: SpaceX is leading the way in developing space tourism with its Crew Dragon

ILLUSTRATION

Though both companies built the spacecraft to ferry astronauts to and from the ISS, they also plan on selling flights to whoever can afford it, be they academic institutions hoping to conduct research in orbit or deep-pocketed individuals wanting to take the ultimate trip.

Next stop, the ISS

NASA is already anticipating the coming boom of private passengers, announcing back in March that the American space manufacturer Axiom would be building an ISS module to accommodate them. Axiom is also helping to facilitate flights to the station; their first, which will take three private astronauts to the ISS, is planned for mid 2021. There's still a seat going spare but you'll have to pay the $55 million price tag on the ticket.

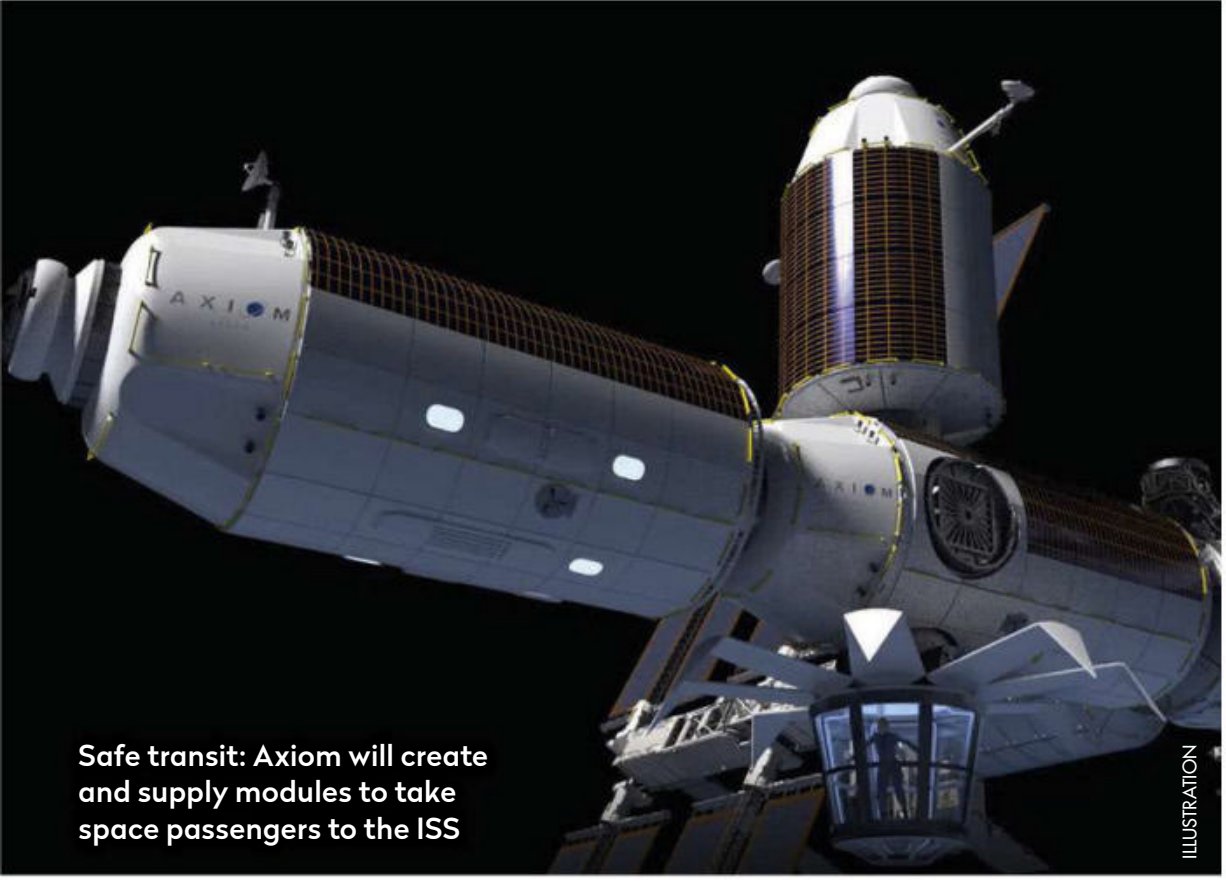
If your budget can stretch to the billions rather than the millions, however, you can always approach private space exploration companies direct for something a little more bespoke than an off-the-shelf flight. Space X is currently working with Japanese billionaire Yusaku Maezawa (pictured right)

In May, NASA astronauts (from left) Doug Hurley and Bob Behnken flew to the ISS with SpaceX

Go back 60 years and the idea of anyone going into space was little more than a dream. Today, more than 550 people have achieved this ambition, journeying beyond our planet and into low Earth orbit. For decades, it's been governments footing the bill for training and flying astronauts, but that could all be about to change. After years of development, private spaceflight is on the verge of being able to regularly carry private passengers, allowing anyone who wants to travel to the stars to do so – provided they have the money, that is.

The company closest to sending people into space is SpaceX. In fact, it has already done so, having completed the first successful human test flight with its Crew Dragon modules in August. Rival Boeing isn't far behind and hopes to have its own Starliner spacecraft certified for humans by the end of 2021. Both companies are remaining tight-lipped about their fees, but a 2015 NASA estimate put the cost of a round trip ticket to the International Space Station (ISS) on a Crew Dragon or Starliner module at around $58 million.

KONSTANTIN SHAKLEIN/ALAMY STOCK PHOTO, UPI/ALAMY STOCK PHOTO, AXIOM SPACE, AFLO CO.LTD/ALAMY STOCK PHOTO, THE NASA LIBRARY/ALAMY STOCK PHOTO



Safe transit: Axiom will create and supply modules to take space passengers to the ISS

ILLUSTRATION

◄ Moon safari: Japanese billionaire Yusaku Maezawa is working with SpaceX on a project to send world-class artists around the Moon

on such a mission, called #dearmoon, which will send six to eight passengers on a flight around the Moon. Maezawa is even giving away his seats, but you'll have to be a world-class artist to stand a chance of getting one; his plan is for all the passengers to create works of art attempting to convey the experience of being in space to the world.

Dr Ezzy Pearson is *BBC Sky at Night Magazine*'s news editor. She gained her PhD in extragalactic astronomy at Cardiff University

At the other end of the fee scale, relatively speaking, is the option of taking a sub-orbital flight with Virgin Galactic. The company promises passengers three things: to cross the boundary into outer space 100km above Earth's surface; to let them see the curvature of Earth; and at least five minutes of free-floating weightlessness.

Ticket to ride

After years of postponements, founder Richard Branson has announced that he hopes to take his own first flight in early 2021, before working down the list of 600 people who have purchased a ticket at the early-bird price of $250,000 – about the cost of the average flat.

While it's nice to daydream, the reality is that most of us could never afford even the six-figure option. There is one more possibility, however – become a professional astronaut. All you need is: excellent physical health; a masters in a physical science, engineering or medicine; several years of work experience; a decorated military history; or over 1,000 hours of flight experience.

If you're applying to NASA, who select around a dozen candidates every few years, then you'll need to have US citizenship. For Europeans there might be a bit more of a fight, as the European Space Agency (ESA) hasn't selected a new class of astronauts since 2008, when 8,414 people applied for just six places. Rumour has it that the agency will be sending out a call for new astronauts in 2021, so it might be time to start working on the CV.

▲ Charles D Walker (back row, left) was sponsored by his employer to go to space

Previous private passengers

Virigin Galactic trips won't be the first time people have paid to go into space

In 1984, American citizen Charles D Walker became the first non-government sponsored person to reach space. His employer, aerospace company McDonnell Douglas, paid for him to fly on three Shuttle missions. NASA charged just $40,000 per flight, though the company spent around $20 million of its own money training him.

Most private spaceflights, however, were not flown on NASA Space Shuttles but on the Russian Soyuz. In the 1990s, the Soviet Union's wider financial problems left its space agency with a shortfall in its ledger, making it more than willing to accommodate paying customers. In 1990, a Japanese broadcasting company paid for reporter Toyohiro Akiyama to fly to the Mir space station, and a few years later Helen Sharman had her flight paid for by various sponsors, becoming the UK's first astronaut.

In 1998, Space Adventures began working with the Russian space agency to broker future flights to the International Space Station (ISS). Since then, the company has trained and flown seven individuals, including the second person to wear the British flag in space, gaming entrepreneur Richard Garriott.

In all these flights, the individuals did more than just float around, looking at the view. Instead, they helped to conduct research and experiments, or put on outreach events to educate those back on Earth.

DIY ASTRONOMY

Turn an unused camera lens into a guidescope

Improve the accuracy of your mount by repurposing an old lens from a camera

Ready to go: the completed camera lens guidescope and camera setup

A guidescope is an important item that helps with autoguiding in astrophotography; it's needed to correct the small errors that can occur when you are tracking with a motorised mount that has mechanical gears. An example is the unwanted image trailing that can occur – even though your mount has a good alignment – when you are taking very long exposures of an object on your main camera. The guidescope and guide camera, along with suitable software, will help to counter this by checking the position of selected stars and communicating with the mount. Importantly, the guidescope makes small corrections to keep your scope stable and fixed on a target object.

There are many purpose-built guidescopes that are commercially available for astrophotography, but it's also possible to make your own – at a reasonably low cost – with the help of some simple DIY skills. The repurposing, or upcycling, of equipment is always a good idea and if it will help you improve your astronomy so much the better. We are going to look at how a guidescope can be made by repurposing an old camera lens. A guidescope itself is basically just a lens on the end of a tube with a fitting for a camera at the other end. This description may sound a bit simplistic, but it got us thinking about how easy it might be to come up with a DIY solution.

Mark Whalebone is a former builder, and is a keen amateur astronomer and tinkerer who lives in Hertfordshire

The aim of this project, therefore, is to make an adaptor that will allow you to attach a guide camera to any lens that you think is suitable for guiding your setup, plus a bracket to attach the lens securely to your scope, without it being too expensive or complicated to achieve. Lots of people have old lenses that date from the pre-digital camera era and there are many for sale on online auction sites at relatively low prices. If you have a modern lens that's going spare you can also use that. This project won't damage your lens; it will actually make it more versatile and you'll be able to easily put it back to use on a regular camera.

A question of size

You may already be wondering about the best size of lens to use; as a low focal ratio is better for picking up stars for your guide camera to track, we wouldn't recommend using a lens less than 50mm. For our project we opted for an old 135mm M42-fit lens with a focal ratio of f/3.5. Your lens also needs to be fairly compact, making it easier to construct a bracket to fit it to a standard finderscope shoe. The DIY bracket could also be used in other areas of astronomy; maybe with a lens as a telescope, or as a finderscope (by inserting an eyepiece instead of a guide camera). Another bonus about our project is that it uses nearly all plastic parts, such as rear lens caps and PVC pipe connectors.

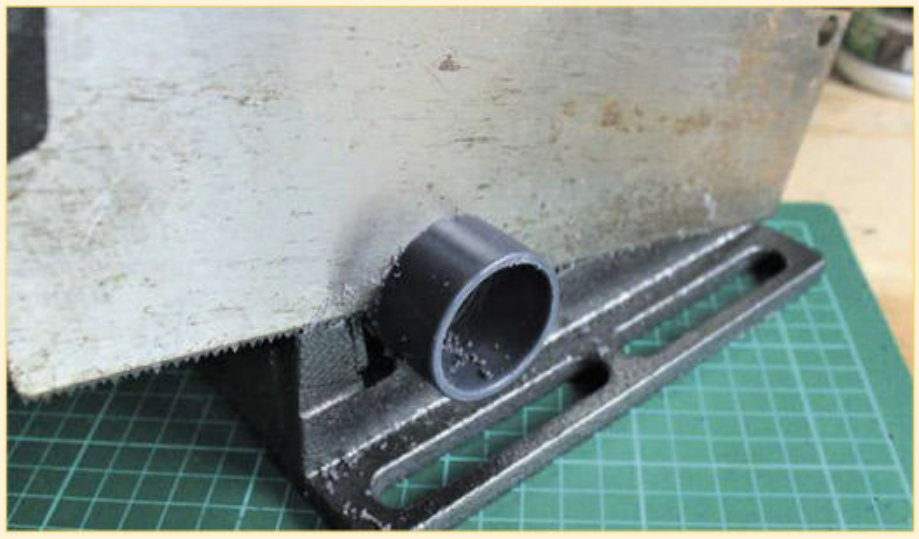
As solvents are used in the guidescope's construction, we recommend that you work in a well-ventilated area. Also, be careful to ensure you have got suitable personal protection when you are using hazardous tools and materials.

What you'll need

- An old camera lens, 50mm or above (we used a 135mm, M42-fit lens)
- A plastic M42-fit rear lens cap (or other suitable plastic rear lens cap); a PVC pipe coupler with an internal diameter of 32mm
- Nine M4 x 16mm nylon bolts to hold the guide camera and lens in place; solvent glue and superglue, files and sandpaper
- Tools include a 36mm hole cutter, a 3mm drill bit, an M4 tap attachment, a hand saw, a drill and an electric screwdriver
- A plastic chopping board and a section of 68mm drainpipe

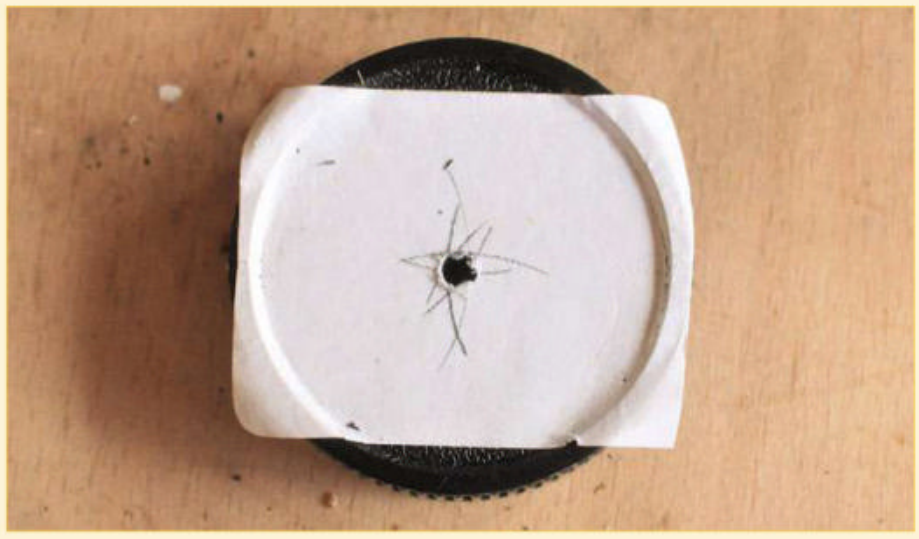
ALL PICTURES: MARK WHALEBONE

Step by step



Step 1

To make the lens-to-camera adaptor, clamp and saw the PVC pipe coupler to the required length; ours was 20mm long to get the correct focal point for the guide camera. Use some fine sandpaper to clean up any rough-cut edges.



Step 2

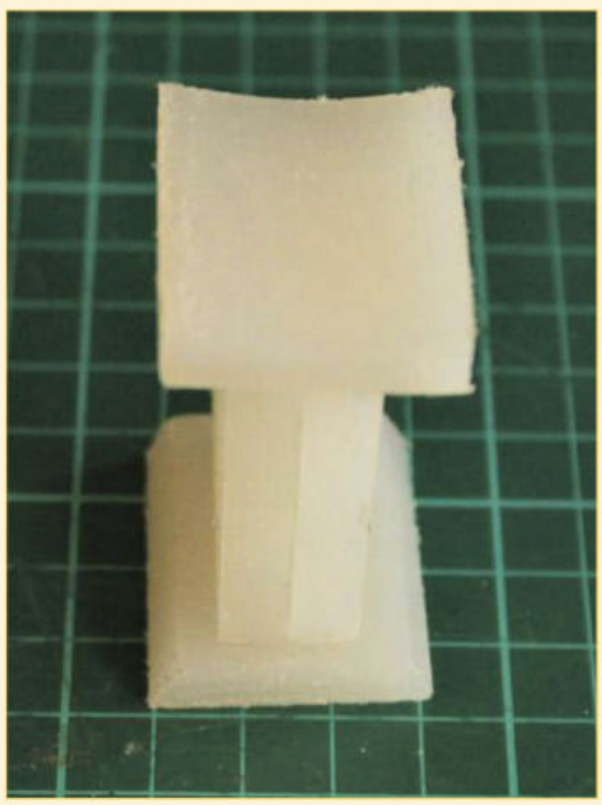
For the adaptor's lens collar, first take the lens cap and drill a 3mm hole in its centre. Then remove most of the flat face with the 36mm hole cutter. We used a compass to draw a circle on a sticky label to accurately mark the centre of the lens cap.

Step 3

After sanding any roughness, carefully apply the plastic solvent glue to the cut edges of the lens cap, making sure not to get any solvent on any threads, then insert the PVC pipe by a couple of millimetres ensuring a nice fit. Allow 24 hours for the glue to set.

Step 4

Now drill three 3mm holes, 10mm from the edge of the PVC pipe and 120° apart. Next, create threads on the insides of drilled holes, by slowly using the electric screwdriver with the M4 tap attachment, before screwing in the M4 nylon bolts. The adaptor is now ready and we can move onto making the bracket.



Step 5

Measure your telescope's findescope shoe and then saw strips from the plastic chopping board and file them for a smooth finish, making sure the strip for the base fits the findershoe. To build the pedestal part of the bracket, glue two strips together for the stem and then glue the base and top to it as shown here.

Step 6

For the lens ring part of the bracket we used a 35mm section of 68mm plastic drain pipe. Make three double sets of M4 locking bolt holes to hold the lens in place (using the method set out in Step 4). Finally, the lens ring is both glued and screwed to the pedestal to finish the bracket. The bracket and adaptor are now ready to use with your lens.

Take the perfect astrophoto with our step-by-step guide

ASTROPHOTOGRAPHY CAPTURE

Catch Neptune and its largest moon, Triton

A careful balance of settings is required to capture the Solar System's outermost planet

▲ **Distant wonders: the ice giant Neptune and its moon Triton are 30 AU from the Sun (where 1 AU or astronomical unit is the distance from the Sun to Earth)**

ALL PICTURES: PETE LAWRENCE

Neptune is a tricky target for astrophotography: being such a distant planet it appears small and dim from Earth. To be fair, as it typically hovers at mag. +7.8 it's only dim compared to its Solar System neighbours.

For imaging the brighter planets, it's normal to use a high frame rate camera configured for short exposures. By capturing frames at a rate of tens (or sometimes hundreds) every second, it's possible to take advantage of the short periods when distortions caused by our atmosphere are at a minimum. These frames are then extracted, aligned and averaged for a decent result.

The lower brightness of Neptune means a bit of balancing is required between gain (amplification, which intensifies an image and makes it brighter but which can also, if set too high, boost frame noise) and exposure. High gain allows a faster frame rate, but the additional noise (unwanted artefacts) means you'll need more frames; lower gain may give cleaner frames, but you'll need longer exposures. The latter results in a lower frame rate that will be less able to overcome seeing distortions. Getting the right balance of settings requires time, experience and patience.

Pete Lawrence is an expert astro imager and a presenter on *The Sky at Night*

Neptune's dimness forces your hand. Here, longer exposures are a necessity and this means lower frame rates. To stand any chance of obtaining detail from the planet you'll need steady seeing and, as you'll be using high magnification, a degree of accuracy in your mount's polar alignment is desirable too.

Triton on the side

One surprising extra is Neptune's largest moon, Triton. At mag. +13.5 this is straightforward to image with a planetary camera; that's as long as you don't mind over-exposing Neptune. In order to catch it, you'll need a setup that can show Neptune as a disc, albeit a rather small one. The orbit of Triton appears as an ellipse, which is separated from Neptune's centre by 3x the planet's apparent disc size at its closest point and 8x at its furthest point. The orbital ellipse has a minor semi-axis of 6 arcseconds and a major semi-axis of 16 arcseconds. This means it's possible to catch Triton more or less at any point in its orbit, it's just a bit easier when closer to an elongation. Through an eyepiece, Neptune has an apparent diameter of 2 arcseconds. Triton, meanwhile, has a diameter of 2,707km and orbits Neptune in the opposite direction to the planet's rotation. Through amateur kit, Triton appears like a blurred star, a consequence of seeing distorting its image, high magnifications and longer exposures.

There are programs and apps to help find where Triton is relative to Neptune such as WinJupos (**jupos.org**). Once you've located Neptune, that odd procedure which requires you to extend the exposure time of a planetary camera beyond what you might be used to, is easy to deal with and will allow you to image the remotest large moon in the Solar System.

Recommended equipment: 200mm or larger telescope, high frame rate planetary camera, optical amplifier, an ADC and a red or luminance filter

✉ Send your images to:
gallery@skyatnightmagazine.com

Step by step

STEP 1

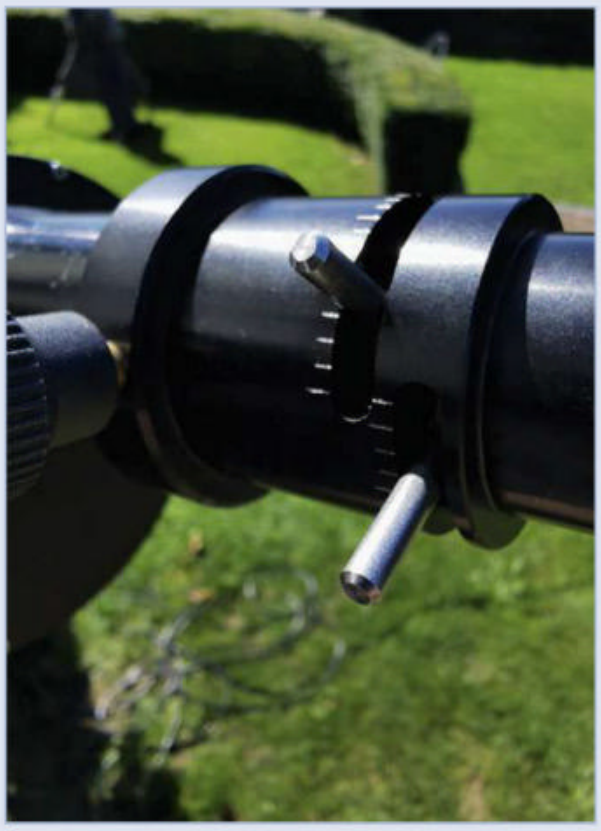
We'd recommend a 200mm scope as the minimum size for this task. Ideally, it needs to be working with a focal ratio of 3–5x the pixel size in microns of your camera. This can be achieved with a Barlow lens or a Powermate. To find your camera's pixel size, look up its specifications on the manufactuer's website.

STEP 2

It's up to you whether you image using a colour or a mono camera. Good results on Neptune's disc can often be achieved using a mono camera and a 610nm (red) filter. However, for Triton, finesse isn't necessary as it's light you're after; a luminance filter (IR+UV blocker) combined with a colour camera will give a bright image.

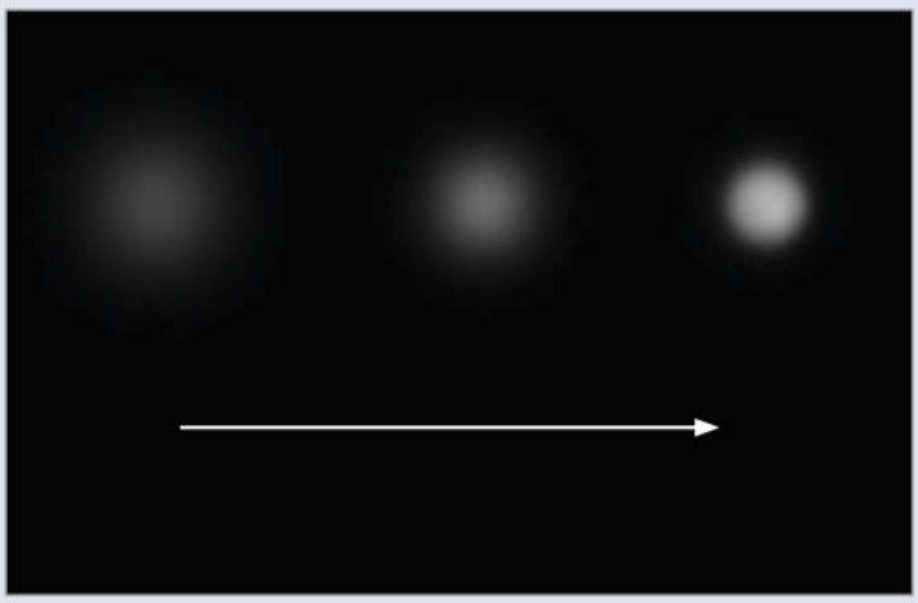
STEP 3

If you image using a colour camera, an atmospheric dispersion corrector (ADC) is useful to remove colour fringing caused by the atmosphere. An ADC has two levers which adjust two internal prisms used to recombine atmospherically dispersed light. Aligned together, the levers should point level with the ground and then be moved apart symmetrically to correct for fringing.



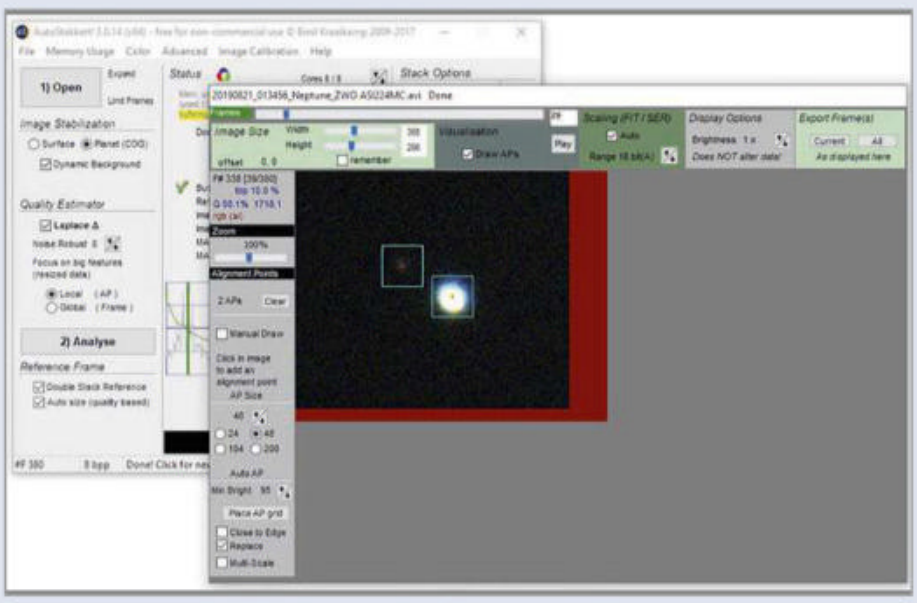
STEP 4

Using a colour camera, over-expose Neptune to reveal colour fringing; then adjust the ADC's levers until it goes. Obviously, mono cameras can't show the fringe colours and here a red-pass filter is recommended to give a view least affected by seeing. Once set up, adjust the gain to 50–70 per cent and the exposure accordingly, to get a correctly exposed view of Neptune.



STEP 5

Focus on the planet as accurately as possible. At high magnification it's recommended that you use an electronic focuser, as this will allow adjustment without having to wobble the scope. Once focused, increase the exposure to reveal Triton near Neptune. If possible, keep the gain at less than 70 per cent.



STEP 6

Once Triton can be seen, start your capture sequence. Aim for several hundred frames as a minimum; it's worth capturing a number of sequences. Once recorded, pass each one through your preferred registration stacking software. In AutoStakkert! you can mark Neptune and Triton for final stacking.

Expert processing tips to enhance your astrophotos

ASTROPHOTOGRAPHY PROCESSING

IIAPY Masterclass

Create a stunning skyscape

How to seamlessly blend two images taken at the same location

Insight Investment
Astronomy Photographer of the Year

Advice from a highly commended 2019 entrant in the 'Skyscapes' category

▲ **Before processing: the initial images, showing the twilight landscape (left) and the later SpaceX launch plume (right)**

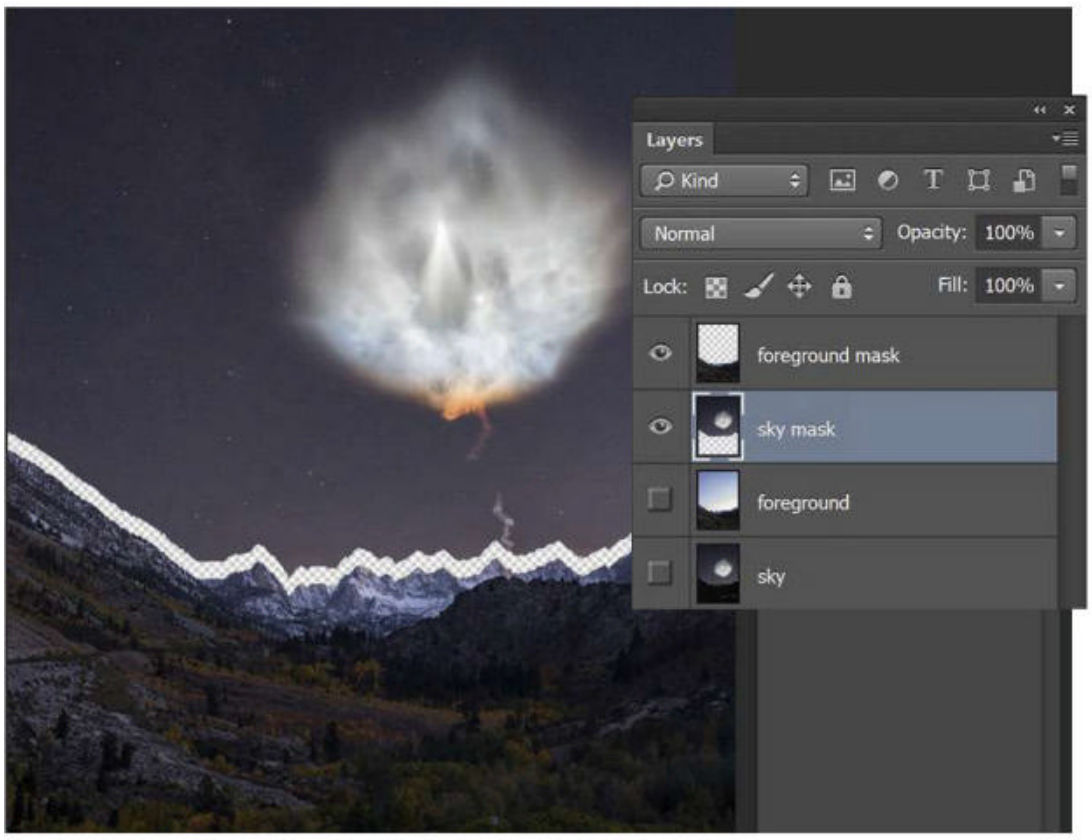
◄ **After processing: Brandon's highly commended 'Flower Power' image**

ALL PICTURES: BRANDON YOSHIZAWA

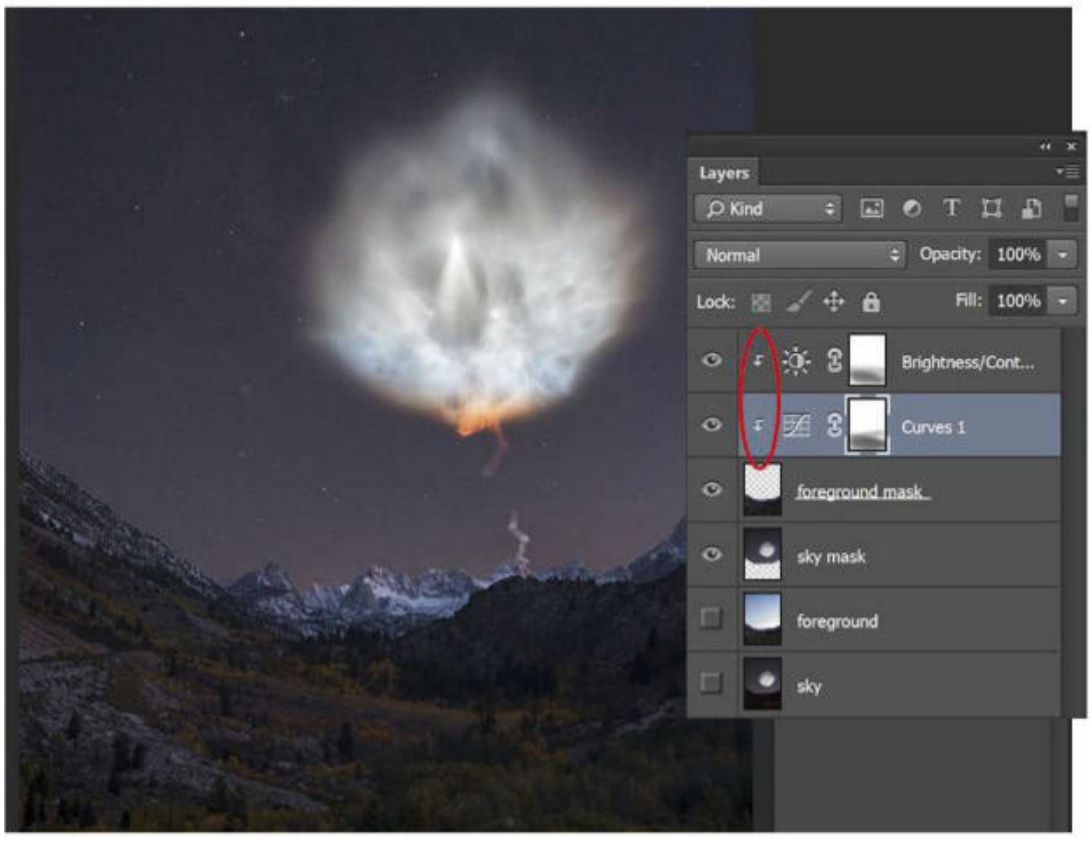
Having planned a trip to California's Eastern Sierra region in autumn 2018, and after scouting around, I found some lovely aspen trees with autumnal colours near the mountain town of Bishop. The gorgeous snow-capped Sierra Nevada mountains provided a great backdrop and I knew it would look stunning in an image as the Milky Way became visible. I was aware of a planned SpaceX rocket launch that evening, but I wasn't sure of the direction, or if it would even be visible from up in the mountains. As the Sun set, I set my foreground exposure and left my camera in place. Towards the end of twilight, I was getting ready to capture the night sky when I suddenly saw a trail of light in my camera's frame of view, rising up from the mountain and beginning to expand. I quickly adjusted my settings and captured shots of the sky as the launch progressed. I couldn't believe how lucky I was to witness the SpaceX launch in such a beautiful setting, in addition to having it happen directly in my camera's view. I was excited to return from the field to edit this amazing event using the techniques described here – in Adobe Lightroom and Photoshop – to combine my images.

Blending together

The first part of the process involves blending the two initial images (see above). To do this you select the foreground exposure captured at twilight, along



▲ **Screenshot 1: the masked areas before they are aligned and combined**



▲ **Screenshot 2: use clipping mask layers to adjust 'Brightness' and 'Curves'**

with the night sky exposure for initial editing and load both images in Adobe Lightroom. Here, you can make general changes to the overall 'Exposure', 'Contrast', 'Whites' balance and 'Highlights' and 'Shadows'. Since the foreground exposure is drastically brighter than the sky exposure, bring down the 'Exposure' and 'Highlights' for the foreground image to mimic what a night exposure would generally look like; and bring up the 'Exposure' and 'Shadows' in the night sky shot to compensate for underexposure. Once both images have been adjusted in Lightroom, they can be loaded in Adobe Photoshop for blending and final editing.

In this particular skyscape, the mountain range provides a hard line between the foreground and the sky, which makes it fairly simple to blend the two exposures. After layering both images, select the foreground exposure and use the 'Quick Selection Tool' to outline the foreground below the mountain range. Zoom in to 100% to make final tweaks to the 'marching ants selection'– the area selected by a moving dotted line – to ensure a proper mask and to create a new layer for this selection. Do the same with the sky layer by using the 'Quick Selection Tool' to select the sky above the mountain range and create a new layer for this selection too. Next, hide both the original layers leaving only the two new layers (see screenshot 1).

Use the 'Move Tool' to line up both foreground and sky layers; if you did a careful job with the 'Quick Selection Tool' both layers will be seamless. If not, you might see a white gap between them. At this point, you can go back and redo the layer masks or you can use the 'Clone Stamp Tool' to carefully remove any white gaps. To use the 'Clone Stamp Tool', zoom in to 100%, sample a portion of the sky close to the white gap and then brush over the gap; filling it in with the sky sample. Once complete, your sky and foreground will be seamless. However, the exposure difference between both layers may still make the overall image look unnatural, so a little more processing may be required.

Brandon Yoshizawa is a Los Angeles-based photographer who was highly commended in the IIAPY 2019 'Skyscapes' category with 'Flower Power'

Finishing touches

To adjust the foreground exposure, select your foreground layer and add both a 'Brightness' and a 'Curves' layer. Right click on each layer and select 'Create Clipping Mask', which will clip it to the foreground layer notated by the down arrow icon. Decrease the 'Brightness' and bring down the overall 'Curves' adjustment on each clipped layer until the overall exposure of your foreground matches the sky. You may lose shadow detail by doing this, so create a layer mask for both the 'Brightness' and 'Curves' layers. Select the layer mask and use a black paintbrush to 'undo' or paint back in the details until you are satisfied with how both combined exposures look (see Screenshot 2).

From here, you are free to add final touches to your post-processing to suit your needs, which may consist of additional 'Contrast', using the 'Dodge' and 'Burn' tools to lighten and darken the image, noise removal (to remove unwanted artefacts), final sharpening, colour correction, 'Vibrance' and 'Saturation', plus any final cleanup work such as removing hot pixels or sensor spots.

3 QUICK TIPS

1. Make sure your tripod is stable so that it does not move in between exposures.

2. After using Photoshop's 'Quick Selection Tool' to mask your foreground layer, invert the mask in order to create your sky layer to save time.

3. Ensure the transition from foreground to sky looks as realistic as possible to mimic a night shot.

Your best photos submitted to the magazine this month

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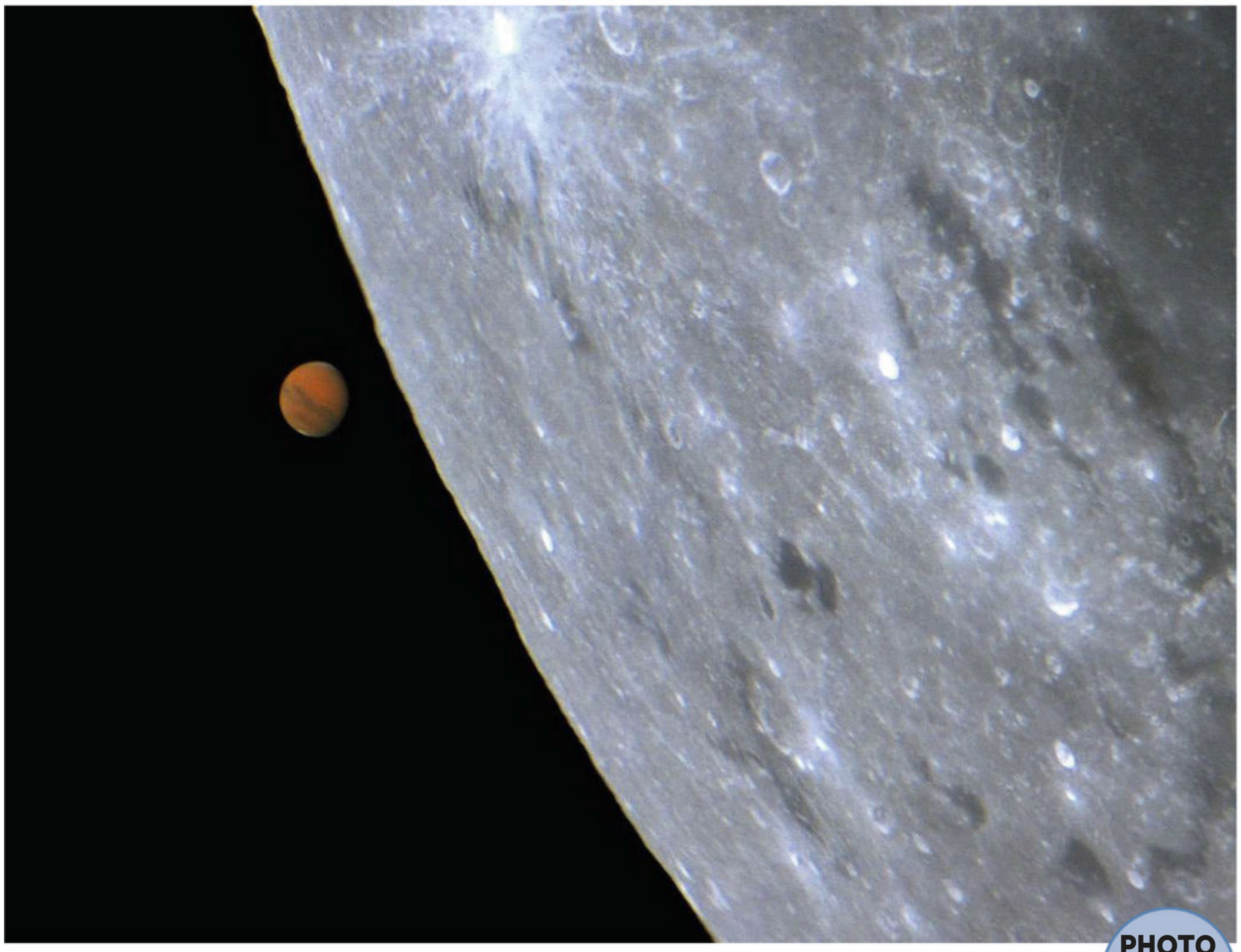


PHOTO OF THE MONTH

△ The Moon occulting Mars

Ricardo J Vaz Tolentino, Belo Horizonte, Brazil, 6 September 2020

Ricardo says: "Despite the adverse conditions – atmospheric turbulence, dew, wind and cold – I managed to capture this beautiful and anxiously awaited astronomical event from my rooftop observatory in Belo Horizonte. The image was taken at 03:02 UT, at the start of the occultation, and is one of an hour-long sequence of photos. By 03:04 UT, Mars had disappeared from view, reappearing 50 minutes later in the southeastern region near the lunar crater Helmholtz."

Equipment: Orion StarShoot Solar System Color Imaging IV camera, Sky-Watcher Skyliner-400P FlexTube Dobsonian, Celestron Ultima 2x Barlow **Exposure:** single exposure **Software:** PhotoImpression

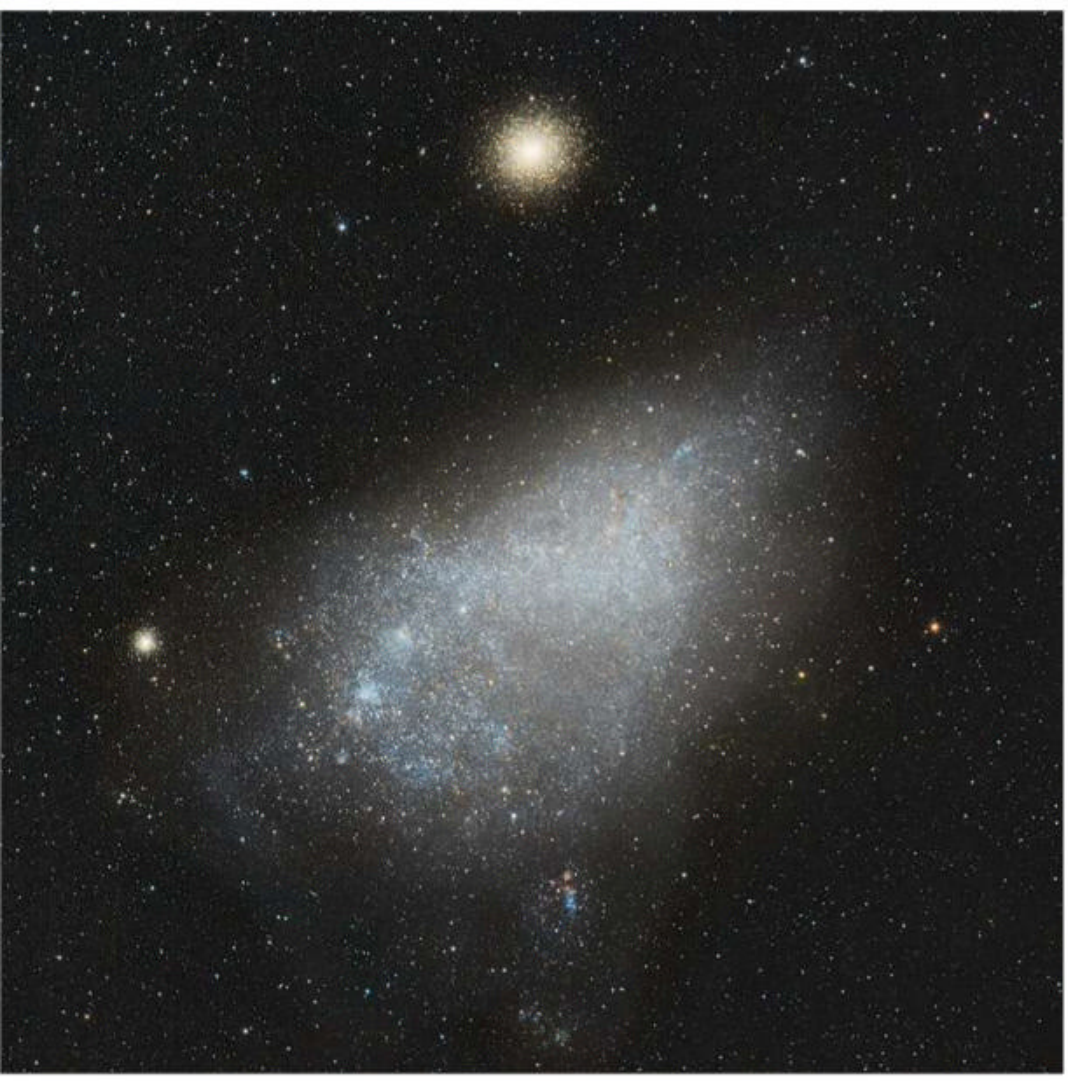
Ricardo's top tips: "To capture the Moon occulting planets, focus ahead of time on the planet that will be hidden and adjust the photo parameters – exposure, brightness, contrast and saturation. Then, focus on the Moon to see if these parameters also suit it; if they don't you'll need to find a middle ground. Precise focus is vital, but you must hope that there's no atmospheric turbulence or wind at the moment of occultation."

△ The Milky Way

Kat Lawman, Dorset, 24 May 2020

Kat says: "I got my first ever DSLR as a birthday gift this year and I knew the first picture I wanted to take was of the night sky. On a clear night we set off to Durdle Door in Dorset. This was the very first Milky Way picture that I took that night, sat on the beach with a hot chocolate at 2am in my sleeping bag and blanket!"

Equipment: Canon 6D Mark II DSLR camera, Samyang 14mm lens **Exposure:** ISO 3200 f/2.8, 45 x 25" **Software:** Sequator, Lightroom, Photoshop



△ The Pleiades

Robert Leach, Corfu, Greece, 28 August 2020

Robert says: "I only started this hobby in May and I'm hooked – so much so that when I took a last-minute holiday to Corfu, I took my equipment with me. I was really excited to image in darker skies (Bortle 2) and happy to capture the nebulosity around the Pleiades."

Equipment: ZWO ASI 183MC colour camera, William Optics RedCat 51 apo refractor, Sky-Watcher Star Adventurer mount **Exposure:** 22 x 600", 45 x 180" **Software:** DeepSkyStacker, PixInsight, Photoshop

◁ Small Magellanic Cloud

Fernando Menezes, Brazil, 21–24 July 2020

Fernando says: "The Small Magellanic Cloud is an object loved by all astrophotographers in the Southern Hemisphere, because – together with the Large Magellanic Cloud – it's visible to the naked eye, making the nights much more beautiful."

Equipment: Canon 6D DSLR camera, Canon EF 200mm f/2.8L II USM lens, iOptron SmartEQ mount **Exposure:** 71 x 100" **Software:** PixInsight, Photoshop, SharpCap

△ The Veil Nebulae

Terry Hancock, Grand Mesa Observatory, Colorado, July and August 2020

Terry says: "This was the first-light image taken using the new QHY600 60-megapixel full-frame camera at Grand Mesa Observatory. I post-processed in bi-colour because it helps to keep the very densely packed region of stars under control and best identifies the very faint areas."

Equipment: QHY600 mono camera, Takahashi FSQ-130 apo refractor, Paramount ME mount **Exposure:** Ha 21 x 600", OIII 14 x 600", RGB 11 x 300" **Software:** PixInsight, Photoshop

The Meathook Galaxy, NGC 2442 ▷

Dan Crowson, via Telescope Live, El Sauce Observatory, Chile, March and April 2020

Dan says: "I really like odd galaxies. NGC 2442 has been on my list for years, but I can't see it from my location. I decided to try Telescope Live and I couldn't be happier with the data captured under dark, Chilean skies."

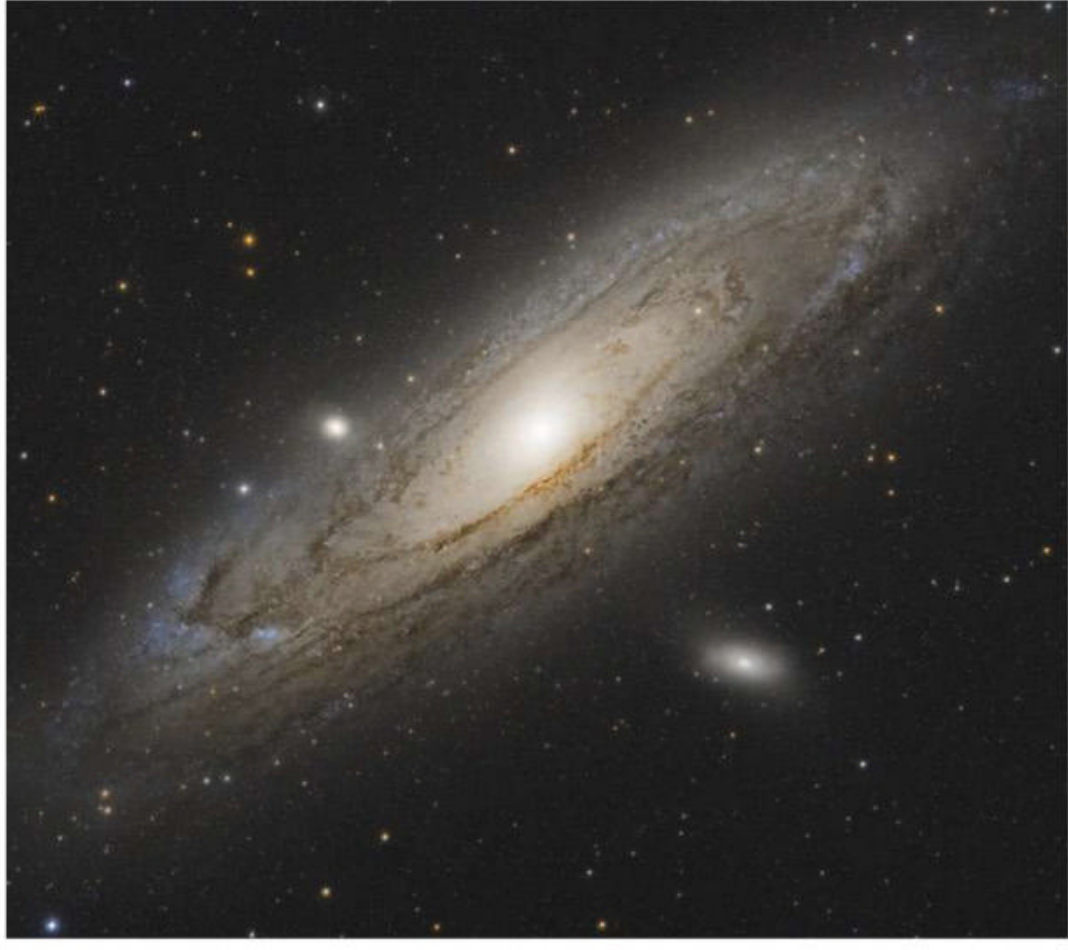
Equipment: FLI PL 16803 mono CCD camera, ASA 500N Newtonian, ASA DDM85 mount **Exposure:** L 9 x 600", RGB 12 x 300" each **Software:** CCDStack, Photoshop

▽ The Bat Nebula

Chad Leader, Maryland, USA, 10 August 2020

Chad says: "I've photographed the Eastern Veil Nebula in a wide-field view many times. I decided to image this section, known as the Bat Nebula, at a longer focal length to see if I could capture the fine details of its wispy filaments."

Equipment: ZWO ASI 294MC Pro colour camera, Celestron EdgeHD 8-inch Schmidt-Cassegrain, Sky-Watcher EQ6-R Pro mount
Exposure: 83 x 300" **Software:** PixInsight



△ The Andromeda Galaxy

Tom Howard, Isle of Wight and Crawley, December 2018 and August 2020

Tom says: "I started this back in 2018 on a holiday to the Isle of Wight, where I recorded 6.5 hours of data. The dark skies meant I didn't use a light pollution filter, which I think helped keep the colours natural. Back at home in Sussex, I added more data this summer: shorter exposures to try to better capture the core and brighter stars."

Equipment: Nikon D7000 DSLR camera, TS-Optics 65mm quadruplet refractor, Sky-Watcher EQ6 mount
Exposure: 78 x 5', 30 x 1' **Software:** DeepSkyStacker, Photoshop

NEOWISE mosaic ▷

Tomáš Slovinský (above), Petr Horálek (below), Slovakia, Crete and Czech Republic, 9 July to 3 August 2020

Tomáš says: "This was an international collaboration, with both of us using the same equipment and settings. I took the foreground panorama of Lomnický Peak in Slovakia and Petr did the processing – his comet data from the Czech Republic and mine from Crete and Slovakia – then we constructed this panorama together. The comet's path is pictured from 9 July on the right to 3 August on the left."

Equipment: Canon 6D, Sigma 50mm lens, Sky-Watcher Star Adventurer mount
Exposure: foreground ISO 10000 f/2.0, 70 x 8"; comet ISO 1250 f/2.2, 30"

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We've teamed up with Modern Astronomy to offer the winner of next month's Gallery a BAADER AstroSolar Safety Film. This specially designed film can be used to make a solar filter for telescopes and binoculars, enabling safe observations of the surface of the Sun. Comes with full safety instructions. www.modernastronomy.com • 020 8763 9953

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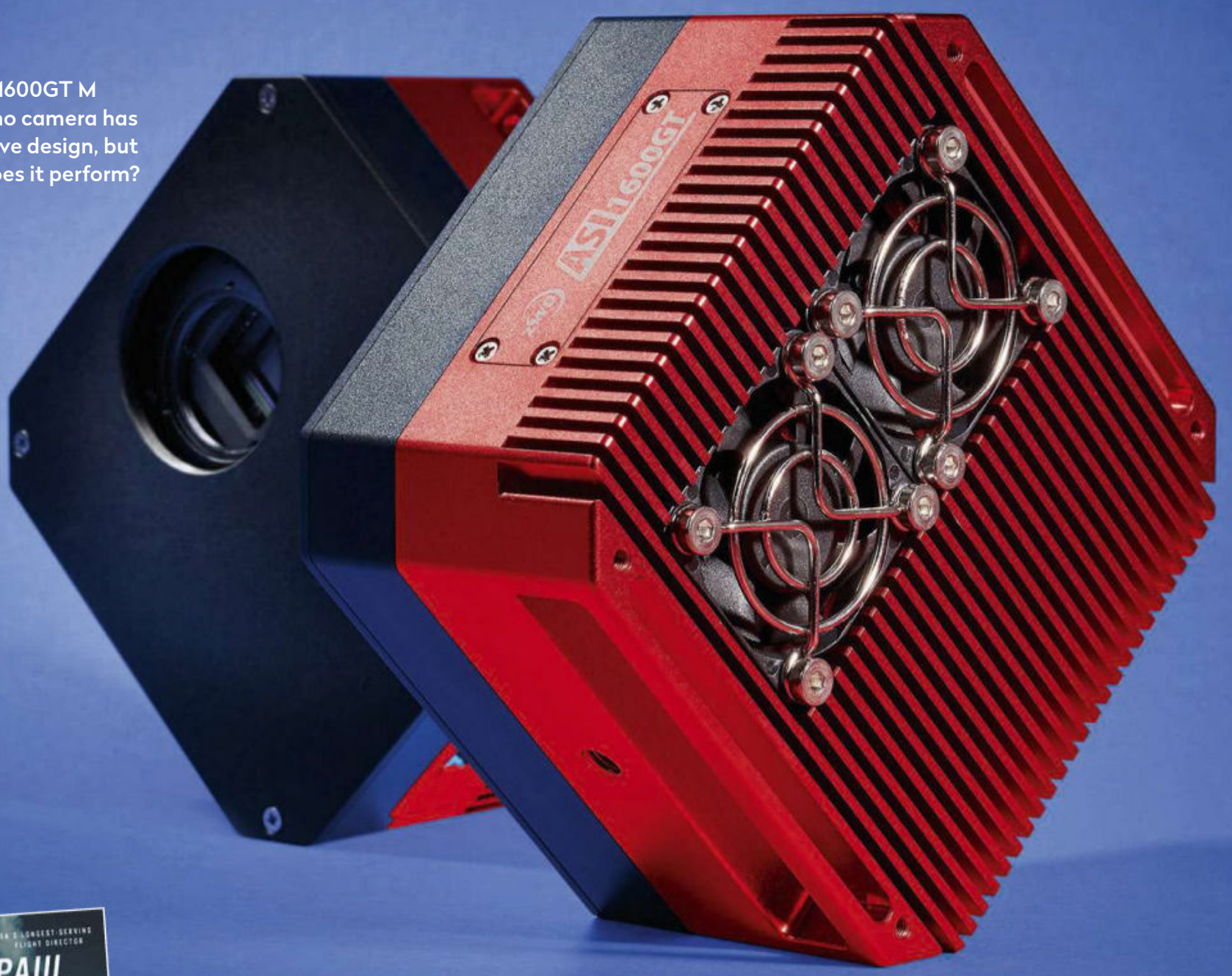
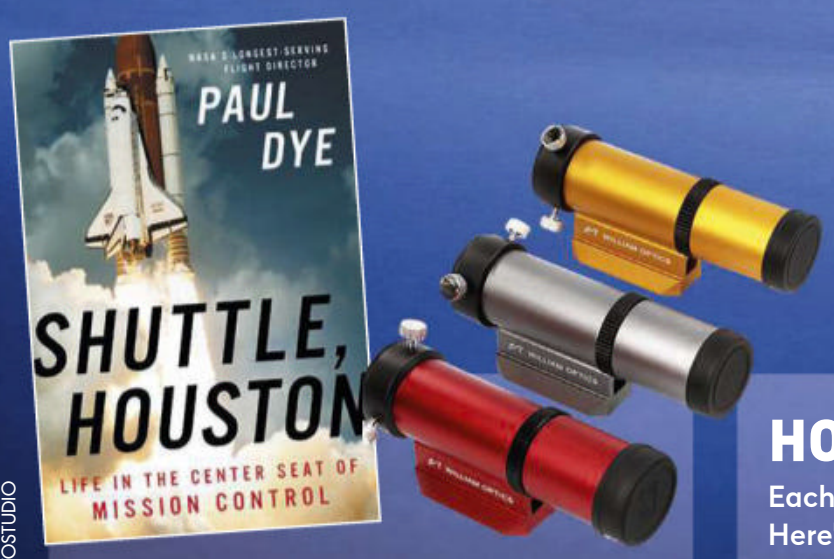
ZWO's ASI 1600GT M cooled mono camera has an innovative design, but how well does it perform?





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HOW WE RATE

Each product we review is rated for performance in five categories. Here's what the ratings mean:

★★★★★ Outstanding ★★★★★ Very good
★★★★★ Good ★★★★★ Average ★★★★★ Poor/avoid

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ZWO ASI 1600GT M camera

A cooled mono CMOS camera with a built-in filter wheel and a stylish square design

WORDS: GARY PALMER

VITAL STATS

- **Price** £1,785
- **Sensor** Panasonic MN34230
- **Image format** 4,656 x 3,520 pixels
- **Pixel size** 3.8µm
- **Full resolution** 23fps
- **Camera size** 110mm x 110mm
- **Weight** 1.10kg
- **Extras** Cables, an extender and spacer adaptors, filter masks, a screwdriver and screws
- **Supplier** 365 Astronomy
- **Tel** 020 3384 5187
- **www.**365astronomy.com

ZWO has become a well-established brand in the CMOS camera marketplace; over the last decade it has produced models for all types of imaging. We are used to seeing the cylindrical shape and red colour of its deep-sky cameras, but now ZWO has launched two new 'GT' models that break with tradition. Here, we take a look at the ASI 1600GT M, a mono camera with a built-in filter wheel.

After opening the 1600GT M's box, we were presented with a square-shaped camera; it's quite a bit larger than a normal ZWO model – with a stylish heatsink back case, two cooling fans and two handles – and finished in anodised red. On the bottom we found a USB 3.0 and two USB 2.0 sockets, plus a 'power in' socket and a new 'power out' socket that can carry 12V to other devices. There is also a red LED power light for when the camera is active, although this has been reduced in size and isn't as bright as on other cameras. The front cover of the camera is black and has four screws; unscrewing these reveals a filter wheel for 1.25-inch filters with space for five.

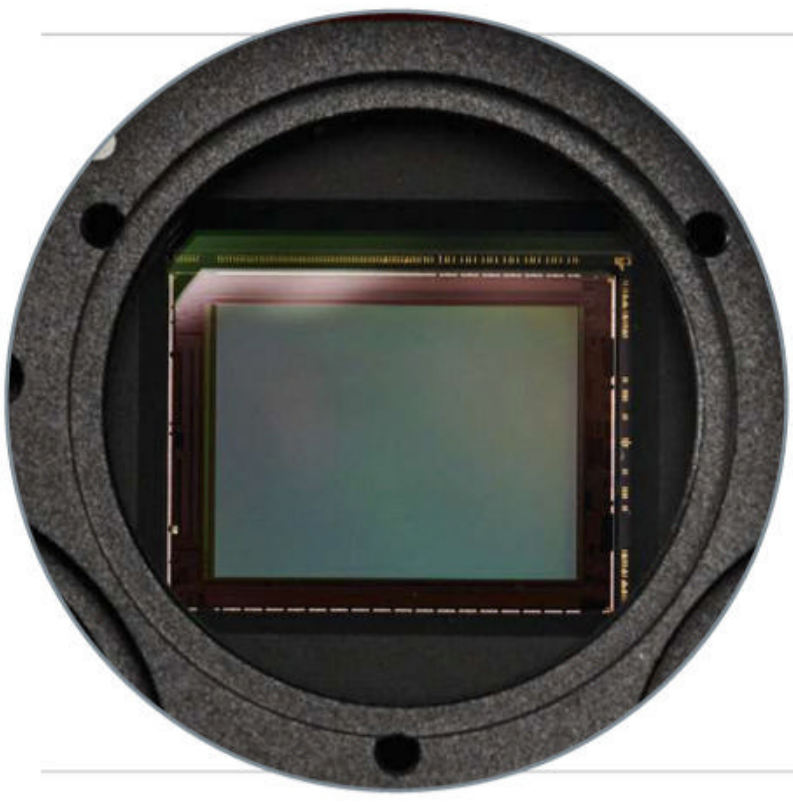
Some care must be taken when installing filters as ZWO is quite specific about the size of thread on these, so it's worth checking the company website (https://astronomy-imaging-camera.com) before installing them; if they are too big the filter wheel could get damaged before you even start imaging. You will also need to visit the website to download the drivers for the camera and the ASCOM driver for the filter wheel (ASCOM is an industry-standard interface that allows different pieces of astronomical equipment to communicate), as these are no longer included on software discs. If you are installing the drivers on a PC, you will also need to have the ASCOM Platform installed there; this will enable you to name the filters and control the filter wheel with software.

The 1600GT mono sensor is a 4/3-inch type with a resolution of 4,646 x 3,520 pixels, while the camera itself has a 256MB DDR3 memory buffer to help with download times. Setting the camera up for imaging is quite straightforward as the adaptors that give 55mm back focus are included in the box.

Test conditions

For the first time in a while we had just two hours of clear sky in a whole month. Luckily, we were able to extend our time with the camera; if we hadn't this review might have been rather short! One of our main concerns was to see if there would be any vignetting. This is when the brightness of an image falls away ▸

ALL PHOTOS: @THESHED/PHOTOSTUDIO



Exceptional sensor experience

Integral to the ZWO ASI 1600GT is the Panasonic MN34230 senor, which has a proven track record for capturing stunning astro images since it was released a few years back. In the early days it suffered from amp glow and other small issues, but ZWO has done some good work to iron out these problems and make its versions of the sensor very clean, with the result that there is little noise (unwanted artefacts) in the final images. The sensor is more commonly known as the ASI 1600 and has a lot to offer in terms of its specifications, starting with a resolution of 4,656 x 3,520 pixels and a pixel size of 3.8µm. There are plenty of custom sizes that can be selected for the camera's region of interest via your camera control software, so you can get a little 'closer' to objects when you are using smaller telescopes.

The camera is also relatively fast for a deep-sky camera at 23fps in full resolution. We found that frame rate increased as we reduced the size of the region of interest, making it very good for lunar and solar imaging – another bonus considering the 1600 GT M is billed as a deep-sky camera.

Cooling system

The rear casing has a heatsink cover with 24 grooves and two maglev fans for additional cooling. Together they allow the camera to cool to 40°C below ambient temperature. This is all easy to control in your favourite capture software and helps to reduce the noise, or unwanted artefacts, in the captured images.

Internal filter wheel

The built-in filter wheel – driven by a silent stepper motor – ticks the box for being easy to use, and is one less item to install. It has five slots that will take 1.25-inch (31mm) filters, which are easy to install by removing the four screws on the front cover.

USB sockets

On the bottom of the camera is a bank of USB sockets, the blue USB is a high-speed USB 3.0 socket which also doubles as a USB2 socket used to operate the camera. Next to it are two USB 2.0 sockets that are used to plug in accessories.

Power sockets

A new feature with this camera is the 'power out' socket. With the option to mount a never-ending list of accessories to use near the camera (for example, an electric focuser or a rotator), more power sockets always come in useful and cut down on the amount of wires running up to the telescope.

Accessories

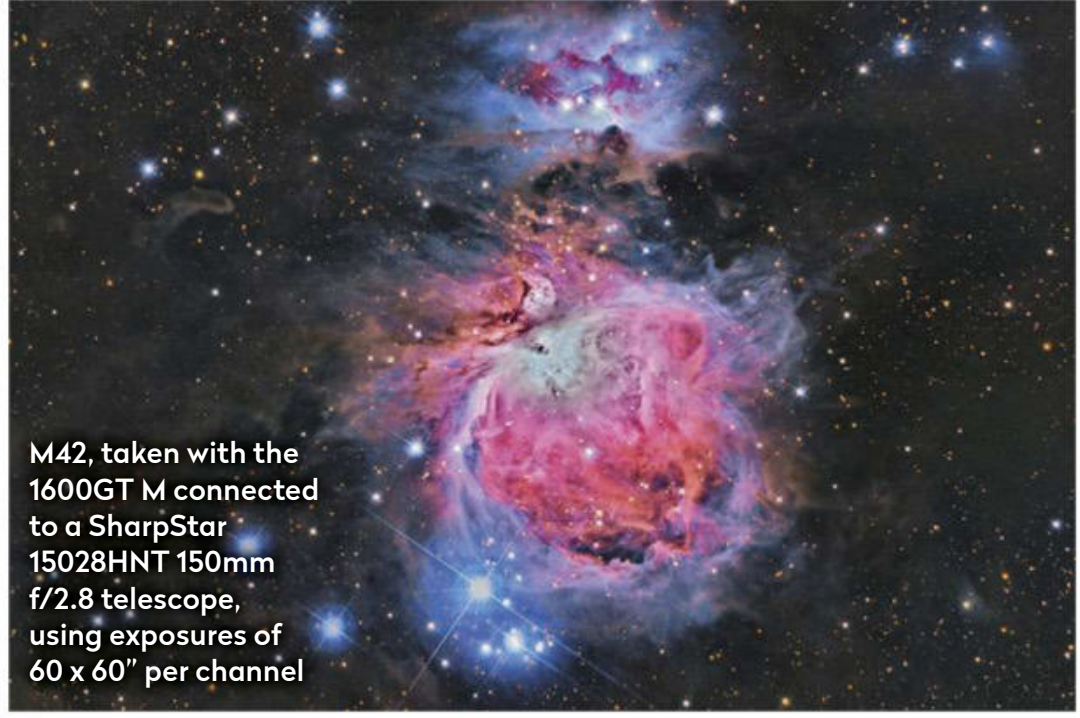
A batch of accessories are included to connect the camera to different equipment. The two extenders give a combined back focus of 55mm for pairing with focal reducers. There's also a screwdriver for removing the main cover, plus extra cables and filter masks with screws.

KIT TO ADD

1. ZWO 12V 5A AC to DC power supply adaptor for ZWO ASI cooled cameras

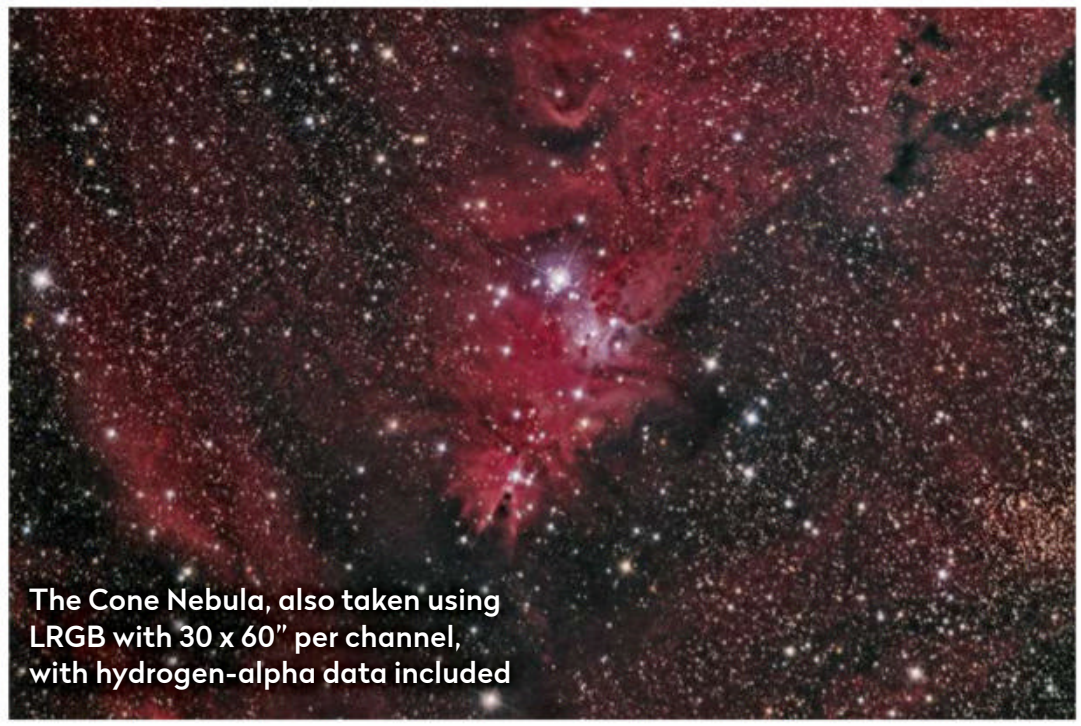
2. ZWO CCD LRGB filter set, 1.25-inch

3. ZWO ASIair PRO smart Wi-Fi accessory



M42, taken with the 1600GT M connected to a SharpStar 15028HNT 150mm f/2.8 telescope, using exposures of 60 x 60" per channel

Galaxy pair M81 (left) and M82, taken with the same setup as above, using 30 x 60" exposures per channel in LRGB



The Cone Nebula, also taken using LRGB with 30 x 60" per channel, with hydrogen-alpha data included

▸ towards the edge of the frame, an aberration which can be caused by small filters being used in conjunction with a large sensor. In order to test this we set the camera up on a scope which delivered a wider field of view. M42 in Orion (pictured right, top) was the first target; we tried fairly short exposures and a low gain as we were using quite a fast imaging system with a focal ratio of f/2.8. Capturing RGB images and processing them revealed no evidence of vignetting, indeed we had detail right to the edge of the field. On other targets, including the M81 and M82 galaxy pair (right, middle) and the Cone Nebula (right, bottom), the 1600GT M performed very well and the filter wheel was very fast and smooth in operation.

When we processed the images we were pleased to see lots of crisp detail with very little noise (unwanted artefacts) considering the imaging times.

Design benefits

The camera may cost is a little over what you would pay for a 1600MM Pro and separate five-position filter wheel, but the 1600GT M has advantages over separate items: there are fewer cables and you can seal the filters inside the camera to stop any problems with dust when not in use. Having the internal filter wheel also avoids any problems with moisture on the sensor window. It would, however, be nice to see a power supply included. You'll need to purchase it separately or use your own and it has to be 5A minimum, bearing in mind that you might be using the 'power out' socket for another device.

Overall, we are pleased to report that the camera performed very well and would be good for anyone who is looking for a mono camera that is easy to use.

VERDICT

Build & Design	★★★★☆
Connectivity	★★★★★
Ease of use	★★★★★
Features	★★★★☆
Imaging quality	★★★★☆
OVERALL	★★★★☆

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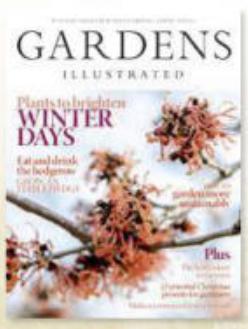

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FIRST LIGHT

Altair Starwave
110ED-R refractor

A portable telescope that delivers detailed views at an enjoyable resolution

WORDS: TIM JARDINE

VITAL STATS

- **Price** £925
- **Optics** Doublet lens with FPL-51 ED element
- **Aperture** 110mm
- **Focal length** 770mm (f/7)
- **Focuser** 2.5-inch rack and pinion with Positive Lock adaptor
- **Extras** Tube rings, Vixen-style dovetail plate and a carry case
- **Weight** 6.8kg
- **Supplier** Altair Astro
- **Tel** 01263 731505
- **www.** altairastro.com

ALL PICTURES: @THESHED/PHOTOSTUDIO

The Altair Starwave 110ED-R refractor is a welcome update to Altair's established product range, the 'R' indicating an upgraded rack and pinion focuser with additional features for an improved experience. Indeed, the improved construction and finish stays true to the reputation of Starwave's telescopes, with smoothly machined fittings and flat silver trimmings, complemented by a luxurious, metallic white paint job. The solid look and feel of the tube assembly has been achieved with the reduction of excessive weight in mind; we were pleasantly surprised about how manageable the telescope was to lift from its aluminium padded case. It was also reassuring to discover – after lugging weighty refractors around over the years – that the 6.8kg Starwave 110ED-R represents an ideal compromise between aperture and portability, offering a large enough 110mm doublet lens for viewing at an enjoyable resolution, while being easy to transport in its protective case.

We found that the balance and length of the Starwave made it an easy fit when it was attached to our EQ mount – sitting neatly in a central position – as the lens cell and focuser are just 60cm apart. This in turn translates into a more comfortable viewing experience for observing objects at a range of altitudes. The upgraded focuser – with its rack and pinion design – makes focusing smooth and precise, while the 1:10 gearing allows easy fine-focusing when the system is used at high magnification. The whole assembly is rotatable, and rather than thumbscrews to hold your eyepiece or camera, a simple twist 'Positive Lock' system is employed. Indeed, once it was tightened and locked in place, we didn't have to worry that this might work loose and release its valuable payload.

Spotting lunar details

For our first viewing session we concentrated on a bright waxing Moon – using our Tele Vue Delos 4.5mm eyepiece – and worked with a magnification of 170x to scan the craters and features near the terminator. It proved to be a rewarding experience, with sharp lunar details along the crater edges and sides. Shadows cast by taller craters and central peaks were crisp and clean, while clearly defined edges within and behind the crater walls indicated the jagged nature of the rims, which are not always as obvious. Enjoying this spell of good seeing we ▸

In a glass of its own

The objective lens of the Starwave is a 110mm, f/7 doublet, with a fluorophosphate, low-index glass element, known as FPL-51 ED. This lens arrangement allows reasonable control of the various colours (or wavelengths) of visible light, bringing them to focus together for a sharper, more pleasing eyepiece view and reducing chromatic aberration when compared to an achromatic lens. Altair Astro informs us that each scope is guaranteed to arrive with properly collimated, or aligned, lenses. The lens cell comes with a matching star test image produced from a double-pass autocollimator. We tested this for ourselves – as the finely tuned collimation of a refractor is essential for viewing close double stars and sharper planet features – and were reassured to see several craterlets within the lunar crater Plato. Doublet refractors require less cool-down time than an equivalent sized triplet telescope, and FPL-51 ED (Extra low dispersion) glass is one of the more thermally stable options, again helping to improve the eyepiece view.

Positive Lock system

The Positive Lock system replaces standard thumbscrews, and tightly clamps 2-inch nosepiece fittings without damaging them. To use it, simply rotate the knurled ring 45° anti-clockwise, insert the nosepiece of your eyepiece or camera, then rotate the ring clockwise to lock it. This attachment unscrews to allow direct fitting of the separately available reducer-flattener lens.

Rack and pinion 2.5-inch focuser

The preferred design choice of many astrophotographers, the smooth rack and pinion focuser extends to a full 95mm, with graduated measurements on the baffled drawtube. Loosening the thumbscrew in the silver ring allows the whole assembly to rotate, making it easy to frame photographs, or to position the focuser for maximum convenience while observing.

CNC tube rings

The Starwave is supplied with lightweight, CNC-machined tube rings and a Vixen-style dovetail plate, all with a good quality finish. There are five M6 threaded holes at the top and bottom of the rings, allowing the secure fitting of accessories, while the flat silver turnscrews match the telescope's finish.

Extending dew shield and screw-on end cap

The well-constructed dew shield extends a full 185mm without sagging, providing protection from stray light and helping to keep moisture from the elements at bay. The dust cap screws firmly into the end of the dew shield, and cannot fall off, further emphasising the build quality of the Starwave.

FIRST LIGHT

Aluminium storage case

A sturdy, well-padded and lockable aluminium storage case is provided with the telescope, making it easy to safely transport and store. Measuring just 775mm x 245mm x 230mm, it is easy to handle and in total – with the Starwave stowed safely inside – weighs just 9.6kg.

KIT TO ADD

1. Altair Starwave 8x reducer

2. Altair 60mm Guide Scope package

3. Altair 180mm telescope carry handle

▸ turned the view to the 101km-wide crater Plato and were pleased to catch glimpses of the four craterlets within.

With a doublet telescope like the Starwave, sometimes called a 'semi-apo', we were expecting to see some colour fringing, especially on a bright object like the Moon. Indeed, there was an indigo fringe around its bright limb, which was especially noticeable with the 4.5mm eyepiece, but considerably less so with our 10mm and almost inconsequential to the view. Unfortunately, Jupiter and Saturn were not ideally positioned during the review period, but we still managed to see some nice colour banding on both planets and (considering the elevation) good variation within Saturn's rings. Mars on the other hand presented an altogether more satisfying spectacle and the bright, multicoated optics of the Starwave presented a remarkable view of the Red Planet at a magnification of 170x, with its distinct polar regions and darker albedo regions clearly visible.

Altair has a dedicated reducer-flattener lens that can be used for astrophotography with the Starwave 110ED-R, but we opted to use the telescope at its normal focal length with both monochrome and colour cameras for comparison. The colour images we obtained, such as of the Dumbbell Nebula, M27, showed a good transmission of colour – including those of hydrogen emission – with some expected blue fringes around brighter stars and a little coma.

Although our imaging time was limited by adverse weather, the Starwave demonstrated its potential appeal to more discerning imagers when we used it with a monochrome camera and narrowband or colour filters. Our image of the Pacman Nebula, NGC 281, revealed features with good definition and contrast, and a favourable imaging scale.

Overall, we found the Starwave 100ED-R was most enjoyable to use, offering a healthy balance between aperture and portability.

VERDICT

Build & design	★★★★★
Ease of use	★★★★½
Features	★★★★½
Imaging Quality	★★★★½
Optics	★★★★½
OVERALL	★★★★½

▲ Top: M27, the Dumbbell Nebula, taken with an Atik 460 OSC camera connected to the Altair Starwave 110ED-R

▲ Middle: a narrowband Ha (hydrogen-alpha) image of the Pacman Nebula, captured after changing the setup to an Atik 460 mono camera

▲ Bottom: The Eastern Veil Nebula, taken with an Atik 460 OSC camera

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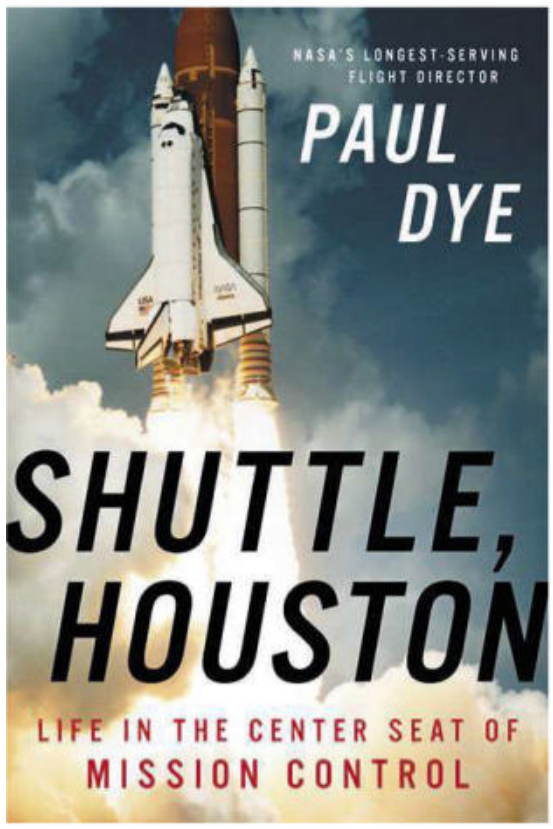


Shuttle, Houston

Paul Dye
Hachette
£20 ● HB

NASA's Space Shuttle programme ran from 1981 to 2011, launching 135 missions, and during that time Paul Dye was its longest-serving flight director. To him, the Shuttle was "...a spacecraft that looked like an airplane and could fly back to a runway... and was what we had all dreamed of while watching Saturday morning cartoons and movies about space travel."

With a clear voice from the onset, Dye deftly crafts the story of his many years working on the Shuttle programme around a broader story of NASA at that time, including the design, planning and implementation of Shuttle missions to Spacelab, the Mir Space Station, the International Space Station and the Hubble Space Telescope. But what is especially appealing in this memoir is the tale of the human effort and meticulous planning behind every one of those 135 missions.

EYE-WITNESS ACCOUNT

Recruited by NASA in 1980, the recently graduated aeronautical engineer Dye began as an intern and then worked in increasingly responsible roles within the US space programme before finally becoming flight director. Sharing significant moments of his career as flight controller and then director, his successes and failures, we are afforded a glimpse of the inner workings of NASA, which is a rare treat: his first visit to a mission control room, working across the hall from the astronauts' office, trips to Russia to plan the Mir missions, being trained by Apollo flight director Gene Kranz, the last Shuttle mission, as well as the Challenger and Columbia disasters.

Devoting whole chapters to spacecraft functionality and orbital mechanics, as well as stories of the training hours, routines and customs of the teams engaged in mission control, the book is somehow both referential and personal, thanks to the author's excellent writing skills.

▲ **Paul Dye in 2006 during his time as flight director of the Shuttle programme**

NASA

Packed with fascinating anecdotes from each mission, Dye attributes people, the expertise of engineers and the quick reaction times of teams as the real measure of success in his career, and the privilege he was afforded in being trained by the best. For anyone with even a passing interest in human spaceflight, this is a must-read. ★★★★★

***Niamh Shaw** is an engineer, lecturer and science communicator*

Interview with the author
Paul Dye

What is the legacy of the Space Shuttle programme?

Probably the International Space Station; the Shuttle was conceived as a way to build and service a low-Earth-orbit space station, and that's what it eventually did. Humanity now considers space as part of its environment and that is what the Shuttle brought us: the knowledge that we are a spacefaring species.

What were the tensest moments during your time as flight director?

During ascent and entry, things can go wrong very badly and very suddenly, but there are times in orbit too, such as when the Shuttle is manoeuvring for docking with a space station. You have to be very careful not to damage the delicate solar arrays with the manoeuvring jets, and not to bump into anything. Space hardware is often very delicate and the slightest bump can cause damage, so everything is done precisely and slowly. Those times can easily be defined as 'tense'.

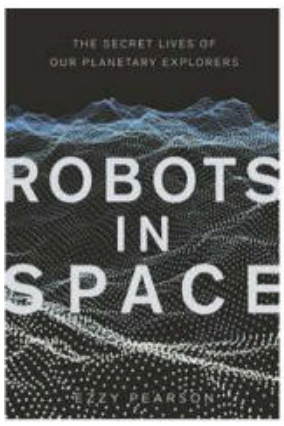
What's your view on NASA's Commercial Crew Program?

I am incredibly happy to see the commercialisation of access to space, and I'm cheering on the companies that are making it work. NASA's purview is exploration and research. Enabling a transportation industry is what NACA did back in the 1930s to foster safe, efficient and reliable air transportation. NASA now is in the process of doing the same thing for commercial space transportation, which will allow them to get on with cutting-edge exploration once again.

***Paul Dye** has over 40 years of aviation experience as an engineer, builder and pilot. He retired from NASA in 2013 as the longest-serving flight director in US history*

Robots in Space

Ezzy Pearson
The History Press
£20 ● HB



What lies under the icy moons of other planets? Is the landscape of Venus like a Garden of Eden or is it more of a hellscape? A few decades ago these questions fell into the realm of science fiction, but thanks to advances in technology, they can all be answered and even evidenced with colourful images. But do we know enough about the robotic explorers that have landed on Venus or dived into the atmosphere of Jupiter to find these answers? Space journalist Ezzy Pearson's first book reveals the heroic story of the robotic planetary landers that have ventured beyond our own world's safety.

"Every year, more and more spacecraft journey out into the void, heading off to another planet, moon, comet or asteroid. Each new mission is another step forward in humankind's push to explore the cosmos around us. And yet, the history of these robotic explorers often goes unremembered," says the author at the start of the book.

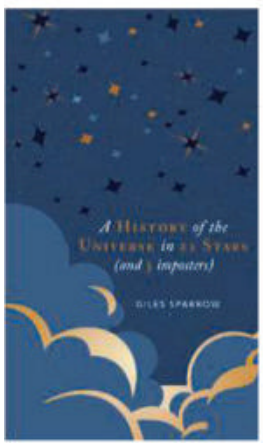
Robots in Space: The Secret Lives of our Planetary Explorers is an excellent debut and a great example of how to tell the story of mechanical devices. The author illustrates space missions not only by explaining their journeys and targets, but also by talking about the people who made the missions a reality. The book's unique angle is the way it combines the stories of success in space with mistakes that have always been present since humanity's first steps towards the Space Age.

This is a very useful book that helps to reveal the 'backstage' activities of the Space Race in the 20th century, and it serves as a fascinating reminder about all the interesting craft that are journeying into space every day. ★★★★★

***Sandra Kropa** is a science journalist and writer*

A History of the Universe in 21 Stars

Giles Sparrow
Welbeck
£12.99 ● HB



Most books that discuss our knowledge of the Universe do so in one of a relatively limited number of ways. They may travel out in space or back in time (though that's actually the same thing! or sometimes give a historical account of discoveries. But *A History of the Universe in 21 Stars (and 3 Imposters)* takes a slightly different – and refreshing – approach.

The book runs through our basic understanding of the motions of the stars, then moves on to different types and what they tell us about how stars evolve, ascending in terms of age and mass of stars (from their birth to their death), before moving on to what we've learned about the Universe on a larger scale – which is where the three 'imposters' come in.

There are a good number of the usual suspects – Polaris, Algol, Betelgeuse etc – but there are some less common examples too. If asked to name 24 key stars, most astronomers probably wouldn't list 61 Cygni or Eta Aquilae, though the reasons for their inclusion become apparent.

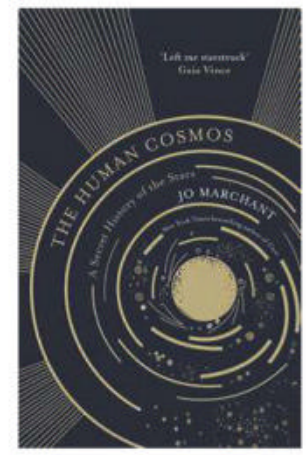
Being generally very easy to read, the style gets slightly more colloquial throughout the book, for example with a few pop culture references in the footnotes that give the impression of increasing familiarity with the author. The illustrations, largely comprising star maps, are clear and complement the professional production quality.

No knowledge of stargazing is required, though a little experience might help make sense of some of the directions. Overall, this is a very pleasant book to read. ★★★★★

***Chris North** is the Odgen Science Lecturer and STFC public engagement fellow*

The Human Cosmos

Jo Marchant
Canongate
£16.99 ● HB



From the first time we looked up at the stars, the whole of humanity has been fundamentally linked to the Universe. In *The Human Cosmos: A Secret History of the Stars*, Jo Marchant explores how our relationship with the stars has evolved and changed every aspect of our lives over the centuries. It journeys from Palaeolithic cave paintings, through our myths, ancient archaeological sites and the rise of religions. It goes on to explore our plotting of the stars and their movements, as well as the rise of science and our ability to probe the composition of the stars themselves and to venture out in search of life beyond our planet.

This fascinating book is meticulously researched and intelligently written. It covers many disciplines, from politics to art, navigation and circadian rhythms, astronomy, religion, biology, the meaning of time and of consciousness itself. It joins the dots to present the big picture of humanity's place in the cosmos, the importance of reconnecting with the awe we feel when we look at the stars, and the dangers of cutting ourselves off from our link to the Universe.

I found myself making notes of things I wanted to explore further, and the extensive reference list has given me lots of scope to dig deeper. Along the way I would have liked to see a few illustrations and images to refer to, when describing particular archaeological sites, art or cave paintings, but in closing I cannot recommend this book highly enough. ★★★★★

***Jenny Winder** is a freelance science writer, astronomer and broadcaster*

Ezzy Pearson rounds up the latest astronomical accessories

GEAR

1 Baader Ultrashort 2-inch eyepiece clamp

Price €67.26 • **Supplier** Baader Planetarium
Tel +49 (0)8145 80890 • **www.baader-planetarium.com**

This eyepiece clamp has a back focus of just 12mm and is threaded on both sides, making it easy to integrate into your observing setup or extension rings. Its sturdy build means it can hold heavy equipment such as Ha (Hydrogen-alpha) filters and CCD cameras.

2 William Optics slide-base UniGuide 32mm guidescope

Price £99 • **Supplier** William Optics
Tel 01353 776199 • **www.widescreen-centre.co.uk**

Keep your imaging setup bang on target with the help of this guidescope. It can attach to many different CCD guide cameras and is adjustable by 25mm to give the crispest focus while tracking your guide stars.

3 Night Sky Underground Map Mug

Price £10 • **Supplier** Royal Museums Greenwich
Tel 01353 776199 • **https://**shop.rmg.co.uk

Navigate nebulae, constellations and planets with this mug that features a map of the London Underground with station names replaced by celestial features.

4 Icebreaker 200 Oasis Deluxe Long Sleeve thermal top

Price £40 • **Supplier** Icebreaker
Tel 0117 456 2355 • **www.snowandrock.com**

This base layer is made from 100 per cent Merino wool, helping to trap heat and keep your core temperature up during the long nights out under the stars. The cut is designed to offer maximum mobility and comfort.

5 Antlia U-Venus Imaging Filter

Price £206 • **Supplier** 365 Astronomy
Tel 020 3384 5187 • **www.365 Astronomy**

ADVANCED The clouds of Venus and Jupiter are beautiful, and this filter reveals those subtle features, with a special coating to bring out UV bandwidths where these features are clearest.

6 Celestial Moon and Constellations Pencil Case

Price from £7.50 • **Supplier** Fawn & Thistle
www.fawnandthistle.com

As well as being a great place to keep stationery, this pencil case is also useful for keeping all the other bits and bobs you need during an observation session. The bag is made from natural-toned linen and features a watercolour sky with the Moon and stars.

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Nisha Beerjeraz-Hoyle interviews Samantha Cristoforetti

Q&A WITH AN ISS ASTRONAUT

Time spent on the International Space Station (ISS) is helping scientists understand the effects that long stays in space have on the human body

What side effects do you experience living on the ISS?
In space your body experiences a lot of changes, although you're not aware of them all. About half of astronauts suffer from something called space adaptation syndrome, which is similar to being seasick and is caused by the disconnect between what you perceive and what your vestibular system is telling your brain. Luckily, I didn't feel sick but I did experience a pressure in my head for about a week. This is brought on by the redistribution of bodily fluids towards the upper body and makes you feel congested; some astronauts feel like they have a cold for their entire stay.

How did your body cope returning to Earth after 200 days in space?
Space adaption is a lot easier because you're moving from effort to effortlessness, but it's the opposite on return as you're going from this absolute lightness to carrying your own weight. You feel incredibly heavy; your brain has to re-learn how to estimate weight and you tend to not use enough force to move objects. The first time I tried to walk after returning to Earth it felt like I was trying to balance a big rock on a couple of toothpicks! Fortunately, this only lasted for 24 hours.

Your cardiovascular system is also fatigued, as your heart and valves readapt to pumping blood around your body against gravity. For the first few days back on Earth, I felt tired and I had an elevated pulse, even at rest. I slept for 12 hours a day; it was my way of gauging that my cardiovascular system was still suffering.

How long was it before your body returned to normal?
We undergo tests before and after a spaceflight and this helps to determine if you've returned back to pre-flight condition. It took about 10 days for my vestibular system to normalise. In terms of our muscles, we come back in good shape because we exercise a lot on the ISS. However, we don't tend to use our postural muscles in space, which help you to sit or stand up straight. These muscles are typically difficult to train in a gym and so they shrink. From the moment you're back you begin activating them again, so they return to normal after a few weeks.

ESA/NASA X 2

▲ ESA's Samantha Cristoforetti exercises on a treadmill on the ISS in 2015. The astronauts use a harness to stop themselves floating away

Samantha Cristoforetti is an Italian European Space Agency astronaut and engineer who spent 200 days on the ISS during 2014 and 2015

What research did you do on the ISS into long duration stays in space?
In weightlessness, you destroy more bone mass than you build anew. One experiment, called NATO (nanoparticle-based countermeasures for microgravity-induced osteoporosis), investigates whether it's possible to maintain bone density by adding specific types of nanoparticles to bone cell cultures. It's not only for the purpose of long duration spaceflight, but also to see if it may be useful clinically.

Were you the object of any of the experiments?
Yes! One investigated how the brain adapts to control balance and movement in the absence of a reference system. For example, your feet on the ground send a signal to your brain on how to maintain balance, which you don't have in space. I had to repeat a series of movements with sensors attached to my body, and we were able to compare the results to a set of data I had completed before the mission.

What are the challenges in getting humans back to the Moon or to Mars?
Astronauts will have to be well trained, because they will have to be more autonomous. On the ISS you can rely on almost real-time communication with an army of specialists on the ground who are there to troubleshoot and help you. As you get further from Earth that's going to become impractical very quickly.

If something goes wrong, astronauts will need to be able to solve the problem in a more autonomous way; they will need to be able to access a repository of knowledge and advanced automatic assistance to help them to troubleshoot any technical malfunctions. The other issue is that there's not much to do on the way to Mars; astronauts will have to cope with a long journey on a spacecraft that is probably going to be small, because it's expensive to send mass to Mars.

► Turn to page 61 to learn more about life on the ISS

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THE SOUTHERN HEMISPHERE

With Glenn Dawes

Look out for the peaks of two meteor showers, the Northern Taurids and the Leonids

When to use this chart

1 Nov at 00:00 AEDT (13:00 UT)
15 Nov at 23:00 AEDT (12:00 UT)
30 Nov at 22:00 AEDT (11:00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

NOVEMBER HIGHLIGHTS

November is a good month for meteor showers. The Northern Taurids are active from 20 October to 10 December, and expected to peak around 12 November. With a radiant near the Pleiades, they are slow moving, often producing colourful fireballs. The Leonids can be seen in November, from the 6th to 30th, with a peak expected on 18th. The radiant is close to the Sickle of Leo. With new Moon on the 15th, the early morning skies on the dates of both peaks should be Moon-free.

STARS AND CONSTELLATIONS

The constellation of Eridanus, the River, flows from Orion into the deep south, ending at its alpha star Achernar. Named from an Arabic phrase meaning 'end of the river', it's the ninth brightest star (mag. +0.45) and hottest of the nine (around 15,727°C). The star has a mass seven times the Sun. Due to Achernar's short rotation period of 2.2 days it's quite oblate in shape, having an equatorial radius 60 per cent greater than its poles. It is the least spherical star known in the Milky Way.

THE PLANETS

Brilliant Jupiter has now moved into the western evening sky with Saturn behind (4° eastward). These gas giants follow the Teapot of Sagittarius, departing just before midnight. Mars is well placed to observe, transiting the meridian mid-evening. Like Mars, Uranus and Neptune are also high in the northern evening sky. Turning to the morning, Venus is dropping towards the Sun and is visible low at dawn, while Mercury can be glimpsed below Venus deep in the brightening sky.

DEEP-SKY OBJECTS

This month we take a deep-sky dive into the constellation of Fornax. The three stars that make up Chi Fornacis are around 6th magnitude and can be viewed with binoculars. Arranged in the shape of a right-angled triangle, they also fit in an eyepiece field (0.5°). The 'right-angle' star, Chi² (RA 3h 27.5m, dec. -35° 41') is the brightest at mag. +5.7 and yellower than its white companions. Chi³ is a double with mag. +6.5 and +10 stars separated by 6.4".

The 'Chi' stars are the gateway to the Fornax 1 Galaxy Cluster. Move 2° to the north-northeast to discover the edge-on spiral galaxy NGC 1380 (RA 3h 36.5m, dec -34° 59'). Glowing at a respectable mag. +9.9, it has a bright halo (3' x 1'), unlike many other fainter galaxies in the group. NGC 1380 is impressive as it features a non-stellar nucleus embedded in a prominent circular core.

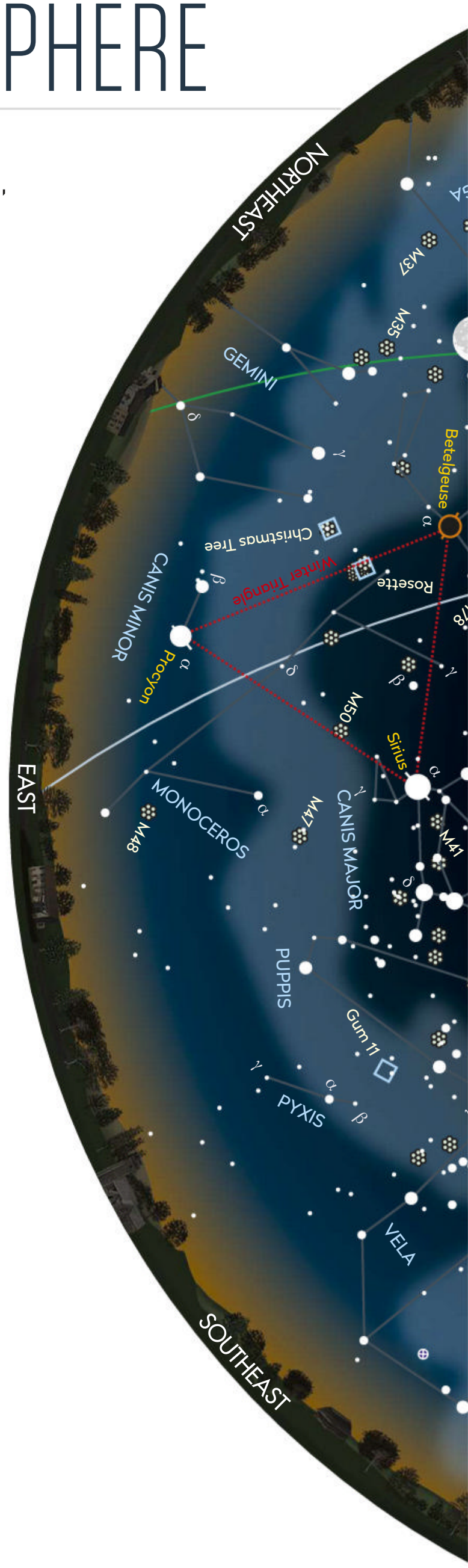
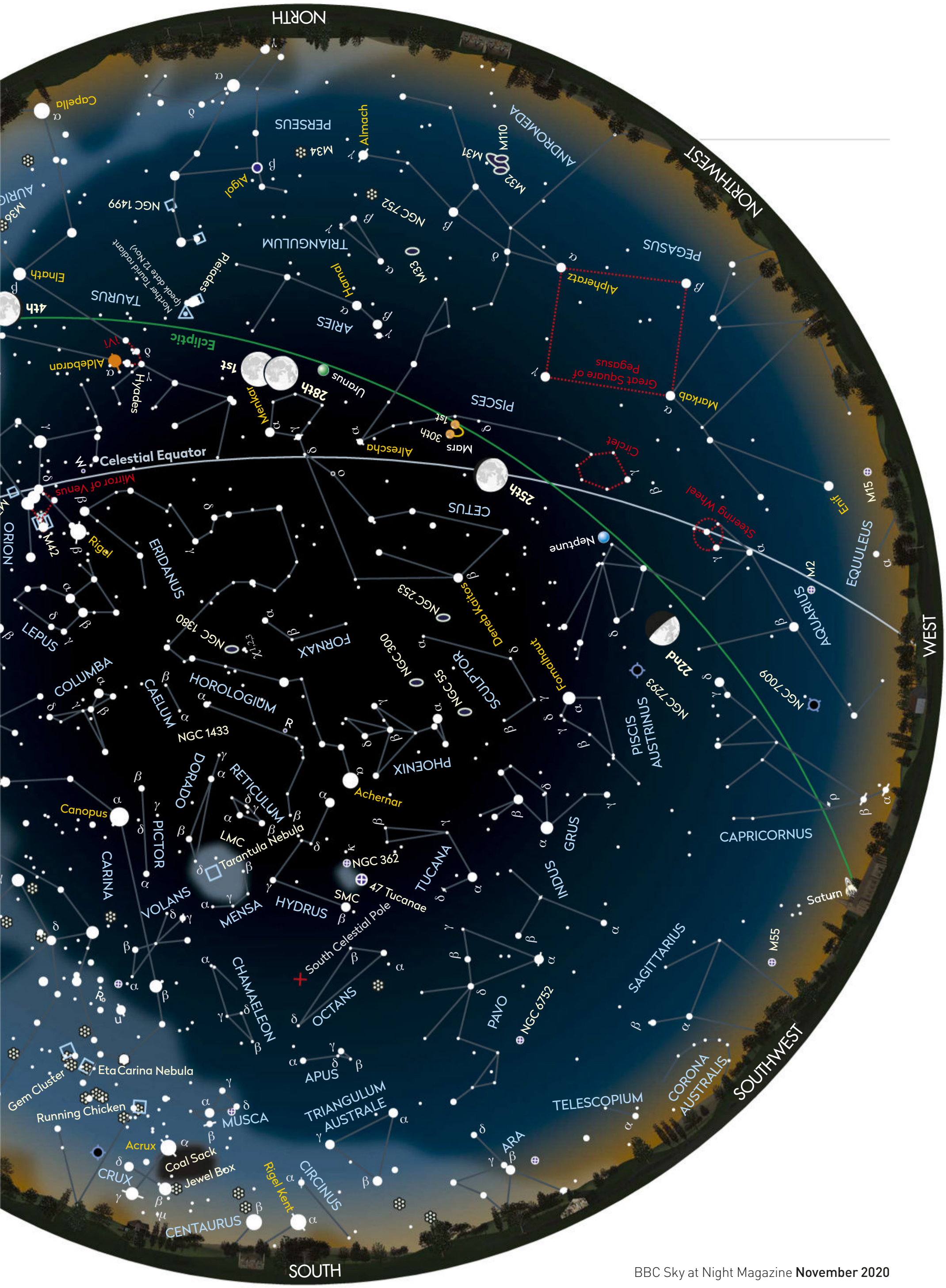


Chart key

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET

STAR BRIGHTNESS:
- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER

CHART: PETE LAWRENCE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NORTHWEST
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M34
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NGC 1499
M36
AURIGA
ANDROMEDA
M110
M31
M32
NGC 752
TRIANGULUM
M33
Hamal
ARIES
Pleiades
(peak date 12 Nov)
Northern Taurid radiant
TAURUS
Elnath
4th
Ecliptic
1st
28th
Uranus
Aldebaran
Hyades
Menkar
Alpheratz
Great Square of Pegasus
Markab
PEGASUS
PISCES
Mars
30th
1st
Alrescha
Celestial Equator
Mirror of Venus
Circlet
25th
CETUS
Steering Wheel
Enif
M15
EQUULEUS
M2
AQUARIUS
Neptune
ORION
M42
Rigel
ERIDANUS
NGC 253
Deneb Kaitos
Fomalhaut
22nd
NGC 7293
NGC 7009
PISCIS AUSTRINUS
LEPUS
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FORNAX
NGC 300
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